Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MAY, 1955

TECHNOLOGY DEPT.

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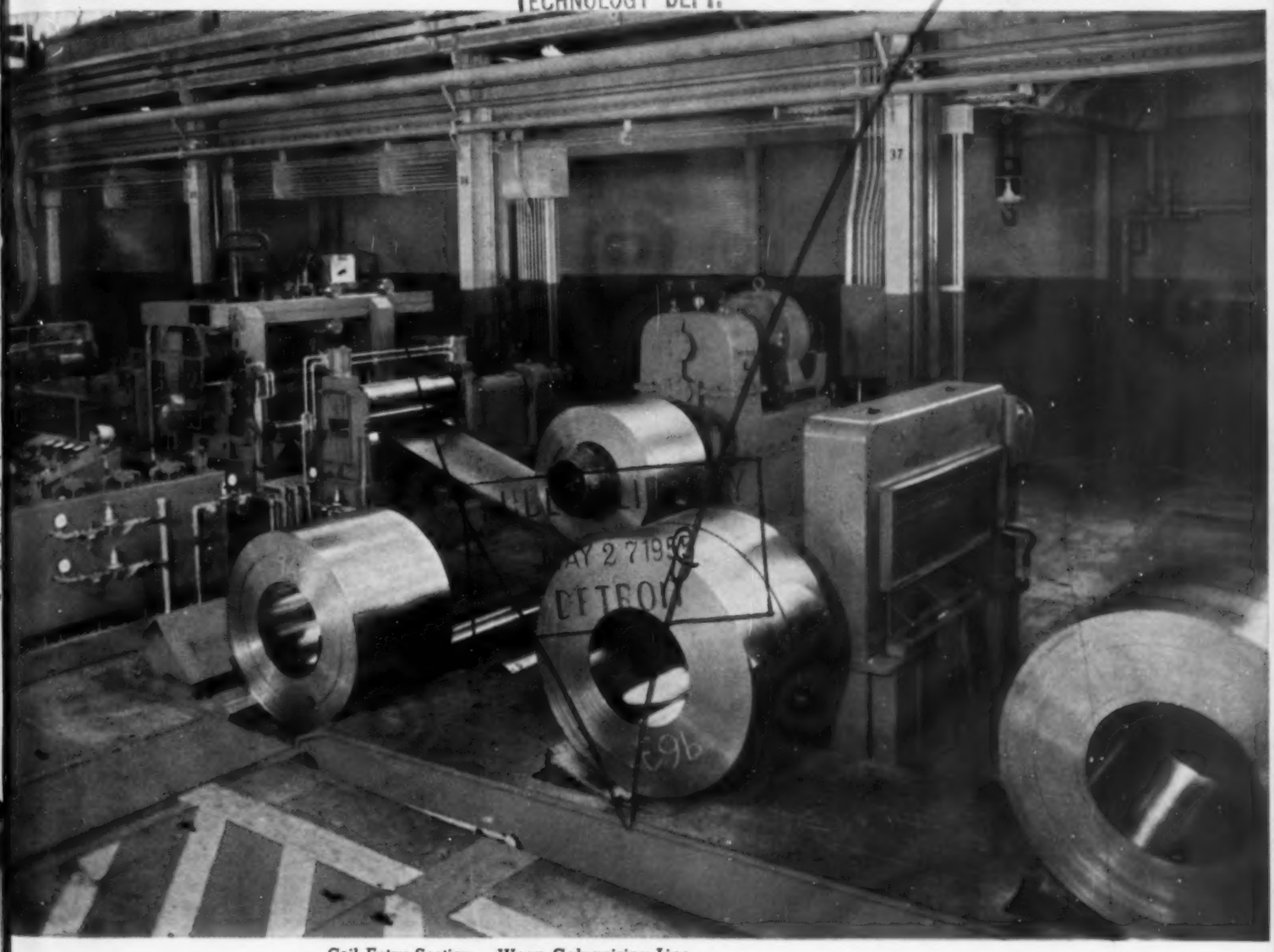


Coil Entry Section — Wean Galvanizing Line

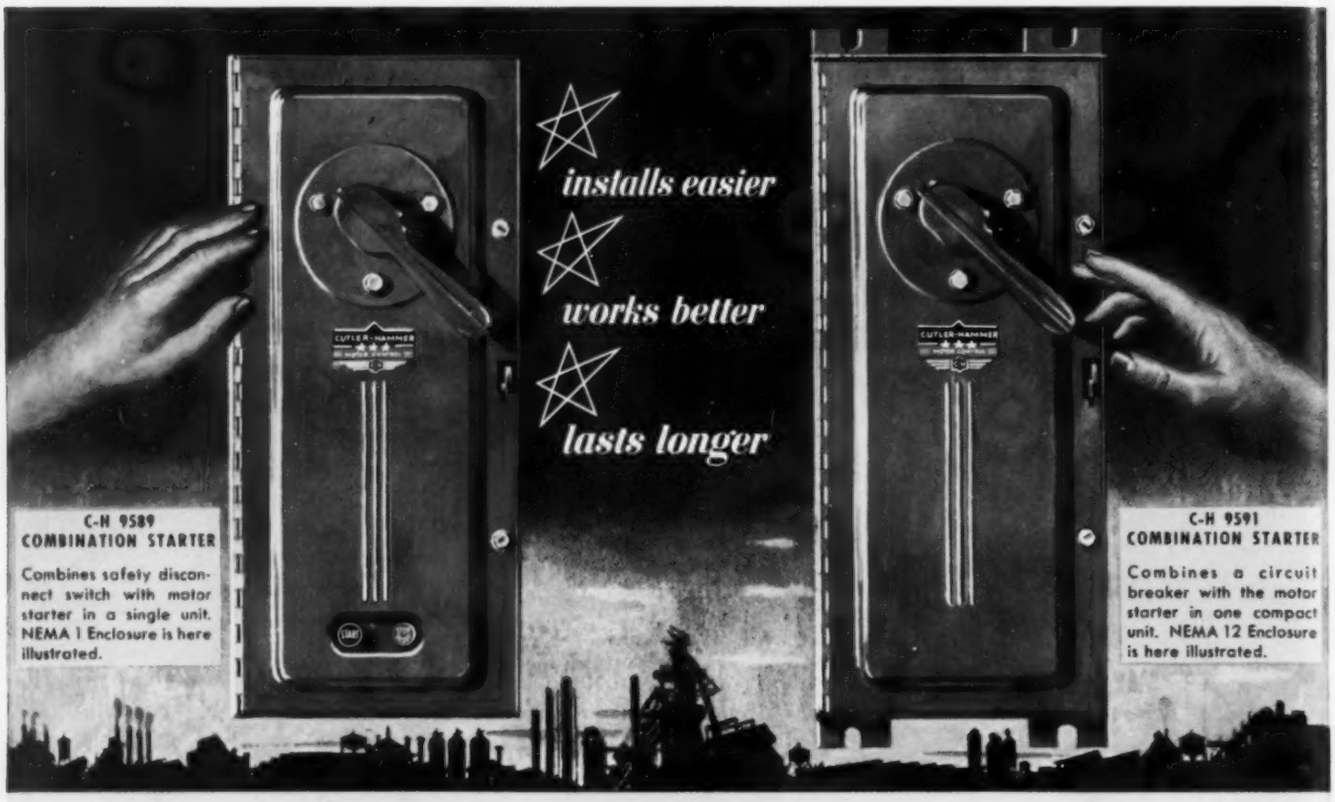
The WEAN ENGINEERING COMPANY · INC.
Warren, Ohio

Typical of Wean Advanced Engineering is this continuous hot dip galvanizing line that produces a vastly improved zinc coat steel at greatly increased speeds. Heavier coatings, tighter bonding and greater uniformity are now possible at reduced costs. It's this kind of never ending search for better ways of making better steel products that has established Wean as the nation's foremost designer and builder of sheet, tin and strip mill equipment.

SPECIALISTS IN SHEET, STRIP AND TIN MILL EQUIPMENT

WHAT'S NEW IN MOTOR CONTROL? ★ ★ ★ GET IT FIRST IN CUTLER-HAMMER

New Combination Starters in the Spectacular Line of Cutler-Hammer ★★★ Motor Control


installs easier
works better
lasts longer
C-H 9589
COMBINATION STARTER
Combines safety disconnect switch with motor starter in a single unit. NEMA 1 Enclosure is here illustrated.
C-H 9591
COMBINATION STARTER
Combines a circuit breaker with the motor starter in one compact unit. NEMA 12 Enclosure is here illustrated.

Users have had many dramatic proofs of the advantages built into Cutler-Hammer ★ ★ ★ Motor Control. They *know* the three silver stars on the Cutler-Hammer nameplate identify control equipment that sets three entirely new standards of motor control performance and value.

Star #1: Amazing savings in installation costs which often exceed the cost of the control.

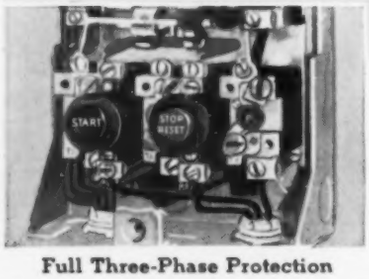
Star #2: Performance so uniform and dependable that *this* control often saves many times its cost by the production interruptions it avoids.

Star #3: Life so greatly increased that this control *never* requires maintenance expense in 90% of its uses.

Now combination starters are available in this spectacular new line of Cutler-Hammer ★ ★ ★ Motor Control. Your nearby Cutler-Hammer Authorized Distributor has been stocked and is ready to serve you. Bulletin 9589 Starters incorporate a rugged disconnect switch of advanced design with or without fuses. Bulletin 9591 Starters are equipped with circuit breakers. Order *now* for prompt delivery.

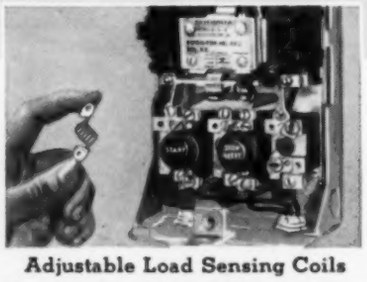
CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER
★ ★ ★
MOTOR CONTROL
C-H



Full Three-Phase Protection

Only *three* overload relays can give complete three-phase protection to avoid motor burn-outs and their costly interruptions to production. And only Cutler-Hammer offers this complete three-phase protection in standard combination starters. You pay only for the third relay, nothing extra for special engineering or special enclosures.



Adjustable Load Sensing Coils

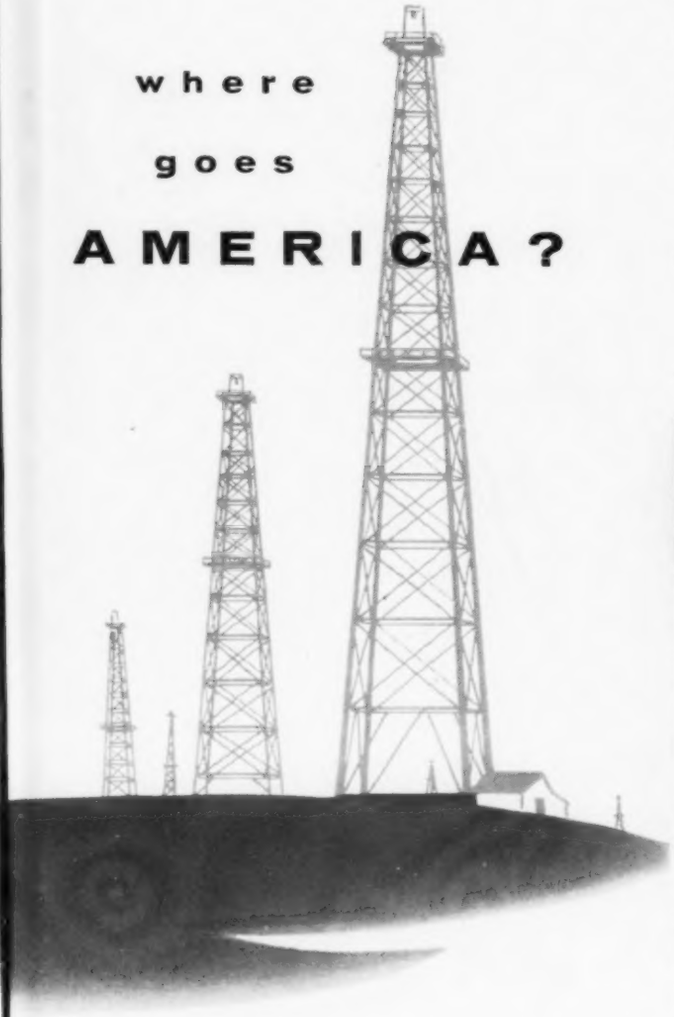
The accurate adjustment of overload protection permits motors to work harder without damage to motor windings. This is more important than ever with the newer type small frame motors. Adjustable load sensing coils in these new starters provide 3% loading accuracy instead of the 10% to 12% accuracy in competitive control.

Superlife Vertical Contacts

Experienced control users insist on dust-safe vertical contacts. And now the famous Cutler-Hammer vertical contacts have been doubly improved. First, their new lightweight design cuts bounce to reduce arcing. Second, any arcing that might occur is now pressure-quenched. Compare performance and see the difference.

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh, Pa. Second class mail privileges authorized at Pittsburgh, Pennsylvania, January 25, 1924.

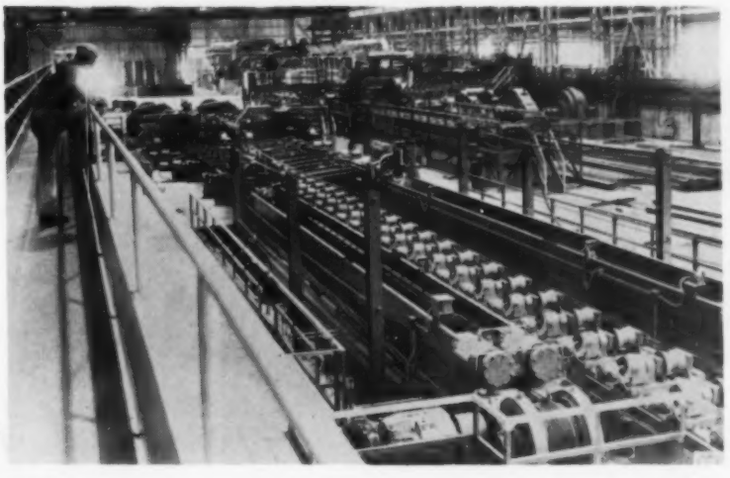
where goes AMERICA?



★ America goes after more and more oil and gas as demands increase . . . up about 5% in 1955. More wells will be drilled, an estimated 54,500. The average depth goes deeper, now down better than 4,000 feet. More and more pipe lines must be built . . . some 14,704 miles planned, approved or authorized. Every year more and more steel is required for production, processing and pipeline transportation per barrel of cubic foot of oil and gas.

All of this activity means more and more oil country goods and much of it will be seamless pipe and tubing.

Are your pipe and tube mills modernized or are you losing out competitively on quality or production?



Most of the ideas about making seamless tubing have been worked out between the steel industry and Aetna-Standard in 54 years association. Many new ideas are available from Aetna-Standard to make your pipe mills more productive. Or, if you are considering new facilities, Aetna has the facts on which to base an intelligent decision.

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

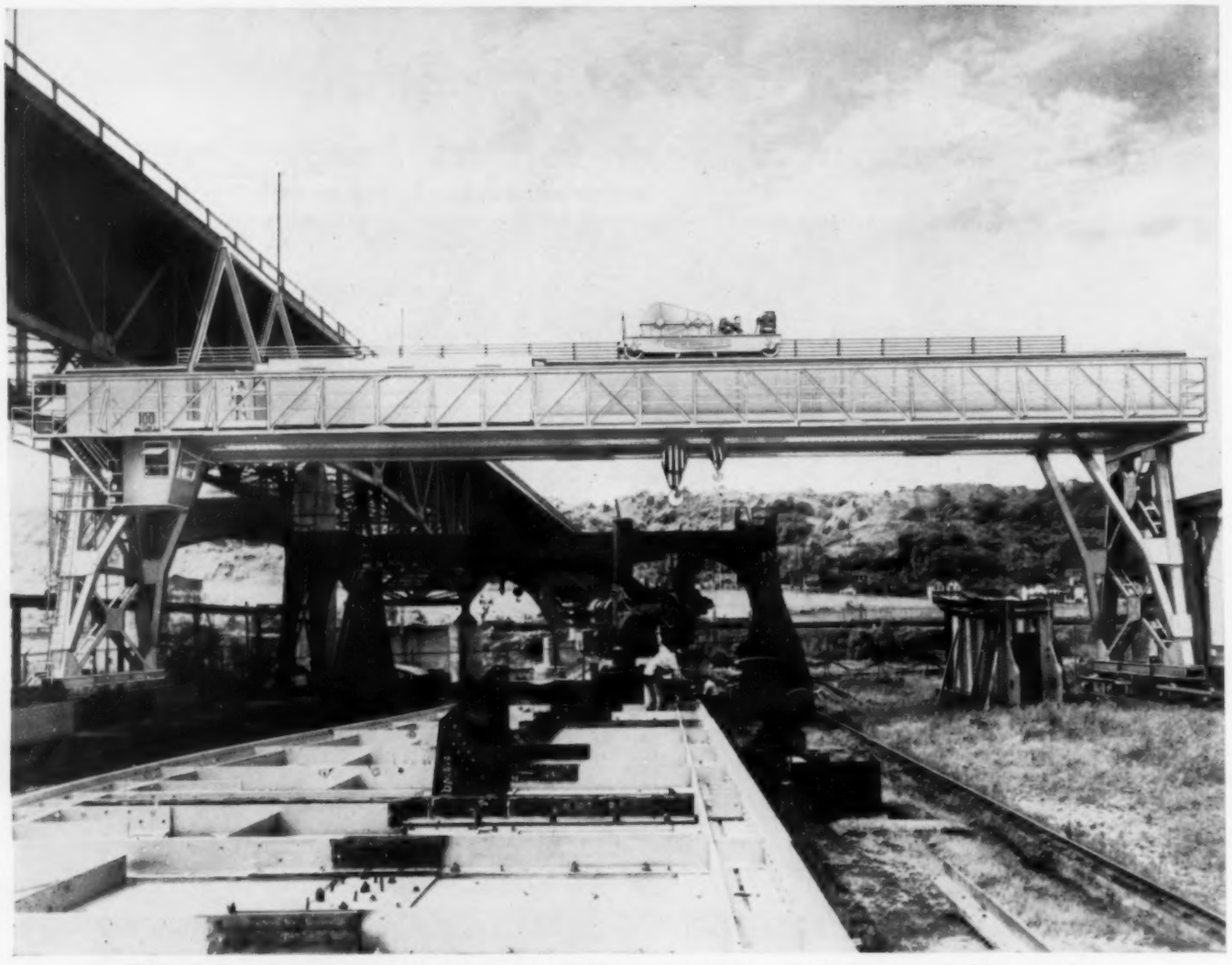
Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

THE AETNA-STANDARD ENGINEERING COMPANY · PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO · ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS



100-ton Bedford gantry crane with 15-ton auxiliary hoist, 130′ span and 30′ lift, owned by a large eastern fabricating plant.

100 Ton Bedford Gantry Crane

This big Bedford gantry crane is equipped with mill type 600 series motors—magnetic dynamic lowering on both main and auxiliary hoists—magnetic reversing plugging control on trolley and bridge motions—Tool Steel Process gears and pinions—eight 36″ straight tread carburized steel bridge wheels. Bridge girders are riveted construction, and each bare girder weighs 92 tons.

All control panels are of the open type, mounted in a walk-in steel control house. Bridge drive is through individual worm drives mounted on each of two bottom bogie trucks controlled by a duplex panel.

The big swing to Bedford Cranes is evidenced by the high percentage of repeat orders from experienced crane users who require and *expect* superior performance.

Backed by more than half a century of *specialized* crane engineering and fabricating experience . . . Bedford Cranes have won fame the world over for advanced design and for safe, smooth dependable performance.

Available in all types and sizes . . . from 5 tons to 350 tons . . . for all kinds of indoor and outdoor service . . . each Bedford Crane is individually engineered for its specific application.

Consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

STEEL MILL CRANES BEDFORD

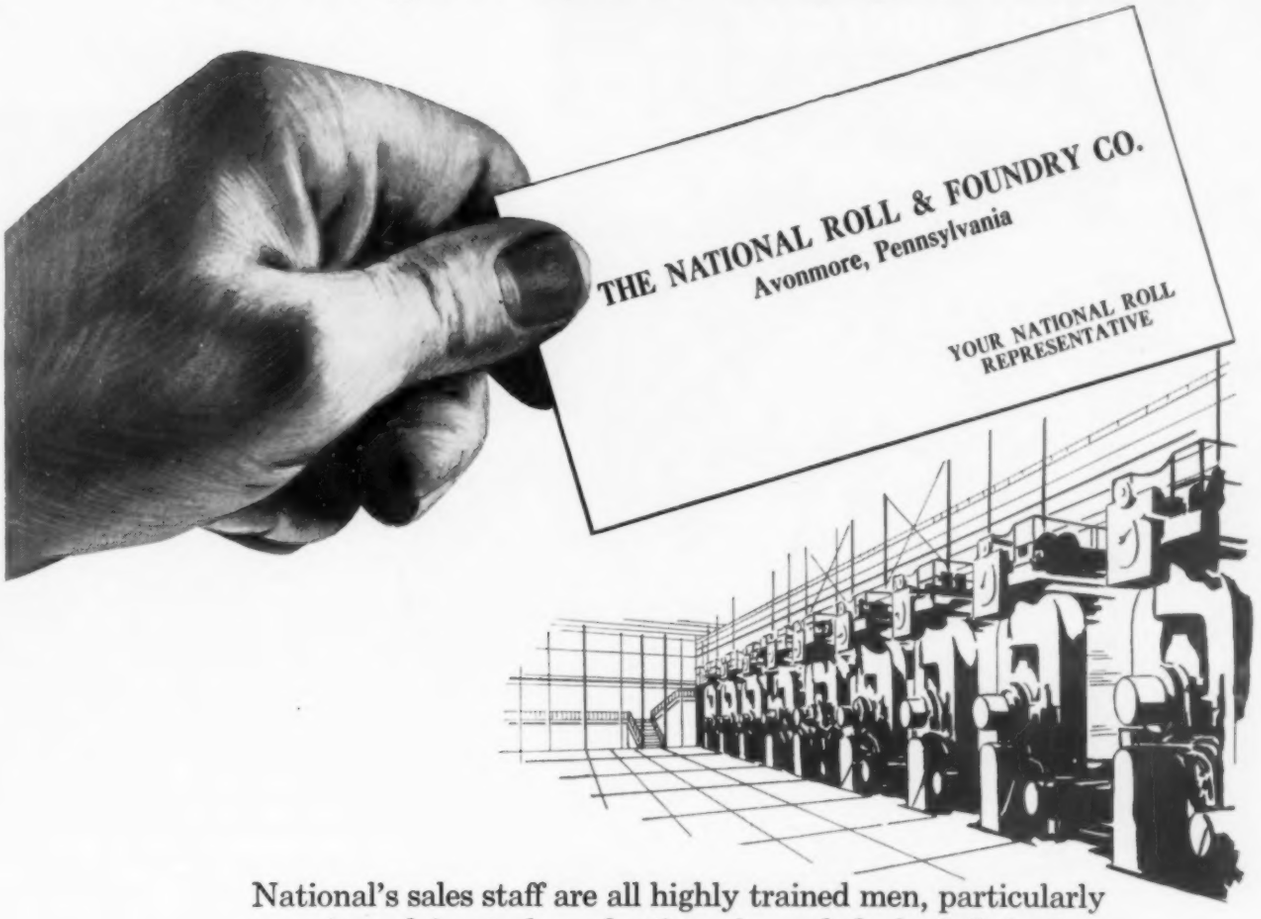
New York Office: 30 Church St., Room 426
New York 7, N. Y., Phone COrtlandt 7-1896

Pittsburgh Office: Oliver Building, Room 1241
Phone ATlantic 1-0136

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

Roll Problems?

Here's a good man to help you lick them



National's sales staff are all highly trained men, particularly experienced in steel production. A good deal of their time is spent in customers' plants analyzing production problems and advising the type of rolls and castings that will do each particular job most satisfactorily.

They are well aware of the many metallurgical and rolling problems that occur and are ready to help you find the solution.

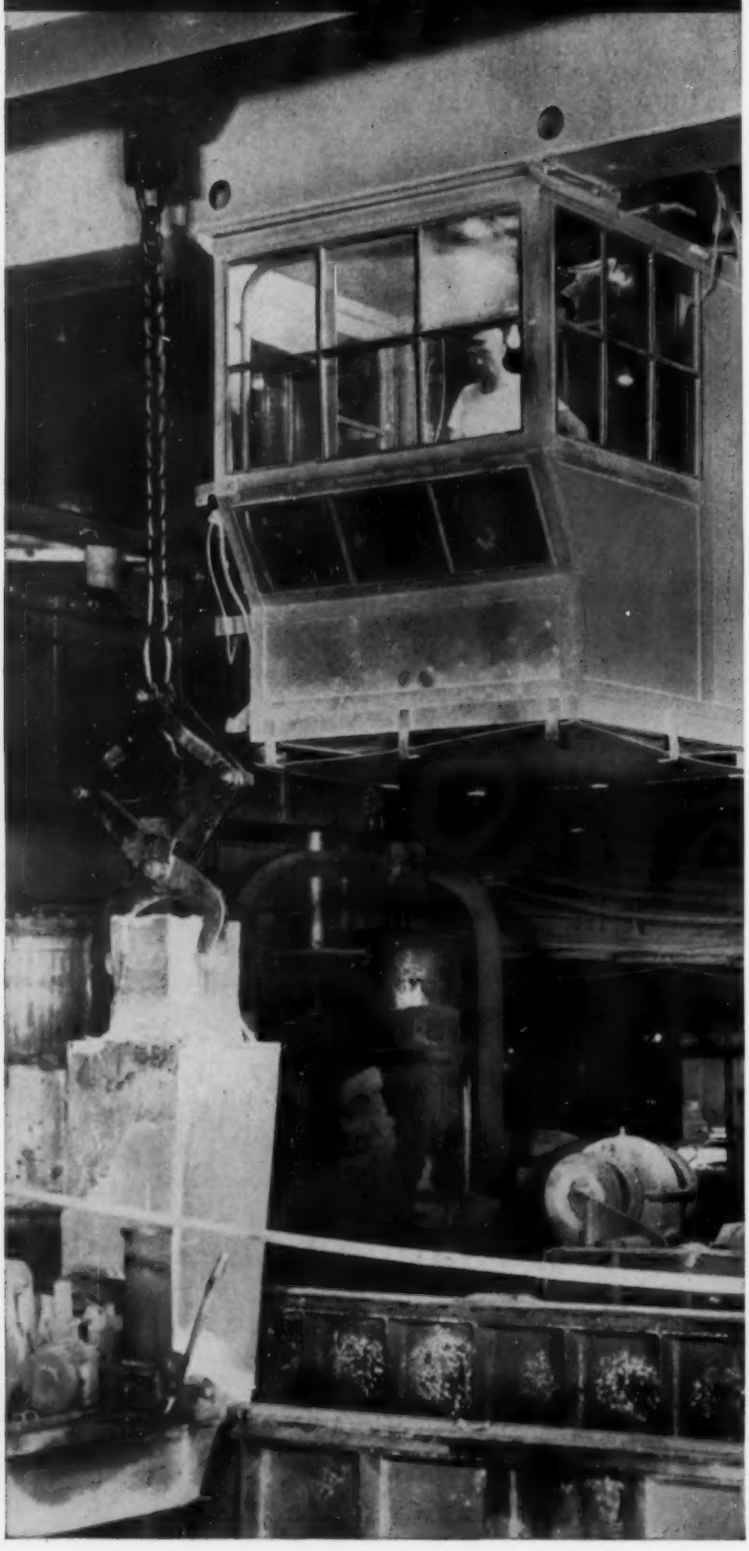
. . . So the next time you run into a production problem, be sure to call on your National Roll representative—he is ready to serve you.

THE NATIONAL ROLL & FOUNDRY CO.

Avonmore, Pennsylvania

Specialists in Iron, Alloy Iron and Steel Rolls and Castings, Steel Armor Castings

Steel mill solves problem of "the 30-minute crane operator"



. . . with DRAVO CRANE CAB CONDITIONERS

In this large Midwestern steel tube mill, heat above the 2300-degree soaking pits was so intense that crane operators had to be relieved every 30 minutes! This "heat-fume" problem was so critical that sometimes an operator collapsed from heat exhaustion and had to be removed for first aid. This was doubly hazardous since the men performing the rescue might also be overcome. Another problem was extremely dense and irritating dust and fumes plus heat encountered by the operator of the charging crane for the new electric furnaces.

Solution to these problems was the installation of Dravo Crane Cab Conditioners on the five cranes serving these "hot spots." Now, every crane operator has ample protection against fatigue and heat prostration. Every operator, alert and efficient in a *78-degree* cab, now works a complete shift without relief.

Because of Dravo Crane Cab Conditioners, the mill not only provided health and safety protection, but *also cut crane operating labor costs in half and increased production efficiency!*

No matter where they're put to work, Dravo Industrial Air Conditioners pay big dividends by providing effective protection from excessive heat, dust, dirt and fumes. We'd like to tell you more about how these efficient, rugged, easy-to-install units can help you. Why not mail the coupon now or phone the nearest Dravo sales office!

DRAVO
CORPORATION
PITTSBURGH, PENNA.
Sales Representatives In Principal Cities

Dravo Corporation, Air Conditioning Department
Fifth and Liberty Avenues, Pittsburgh 22, Penna.

- ☐ Please send Bulletin 1301 "Crane Cab Conditioners."
- ☐ Please send Bulletin 1304 "Cool Off the Hot Spots."
- ☐ Please have a representative call at no obligation to me.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

How Do You Measure Progress?

Progress in rolling mill design is measured in dollars and cents. When a new mill will outdo its predecessor in output, accuracy and conversion costs per ton—that's progress.

The many Morgan mills in operation and under construction are proof that progress in this field is measured with a Morgan yardstick. How about getting our ideas on your new project?

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

Rolling Mills - Morgoil Bearings - Wire Mills
Regenerative Furnace Control - Ejectors - Gas Producers

English Representative: International Construction Company
56 Kingsway, London, W.C. 2, England

RM-61

Above is shown a horizontal-vertical rolling mill built in 1867. Here is the Skelp Mill at National Tube, Fairless, built in 1953.

designed to save manpower and reduce upkeep costs

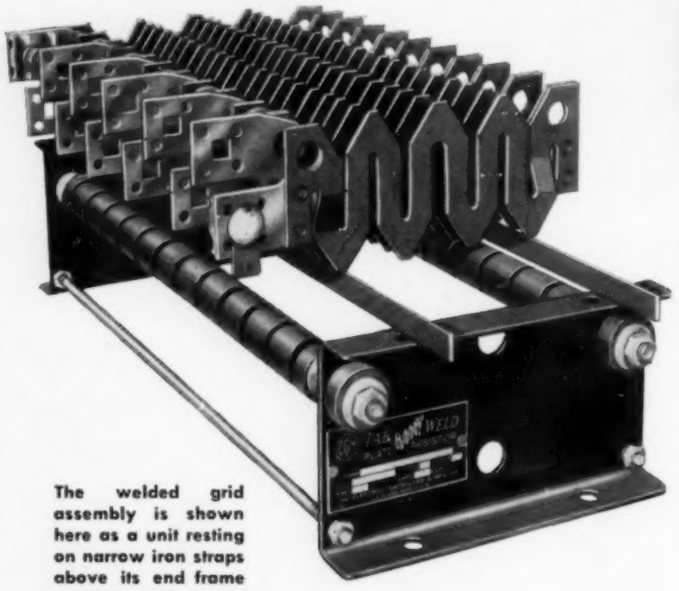
The welded GRID-ASSEMBLY steps up resistor-performance these 3 ways:

1- STABILIZES the ohmic value, independent of the clamping-nuts.

2-STOPS BURNING at grid-eyes and at tap-plates.

3- SIMPLIFIES tap-shifting, when adjusting resistance for best motor operation—also makes it easier to replace sections.

For reduced maintenance where maintenance can be easily overlooked, switch to EC&M Tab-Weld PLATE RESISTORS.

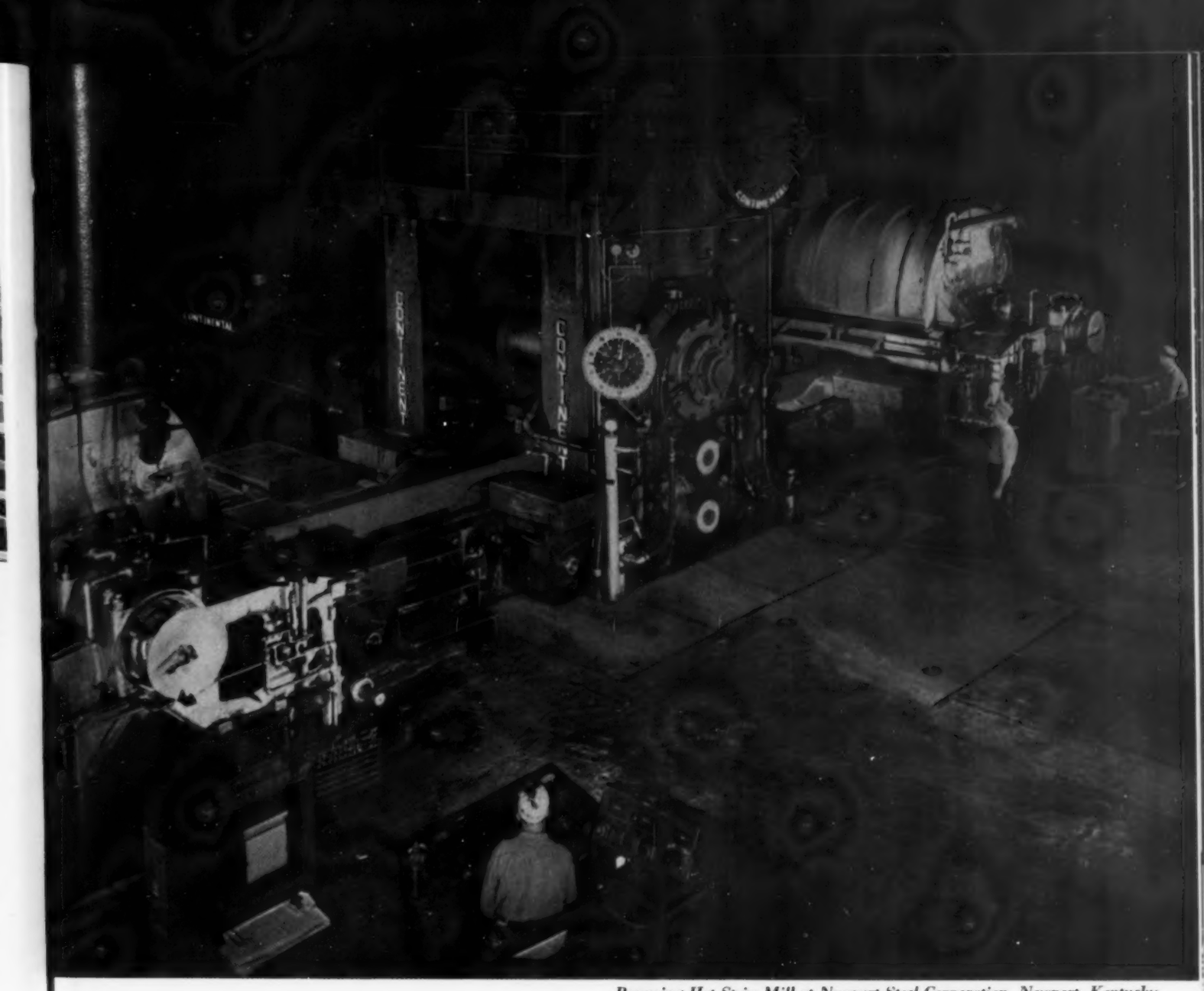


The welded grid assembly is shown here as a unit resting on narrow iron straps above its end frame support rods, and spacers.

SPECIFY BULLETIN **942** *EC&M TAB-WELD RESISTORS*

THE ELECTRIC CONTROLLER & MFG. CO.

4498 LEE ROAD ★ CLEVELAND 28, OHIO



Reversing Hot Strip Mill at Newport Steel Corporation, Newport, Kentucky

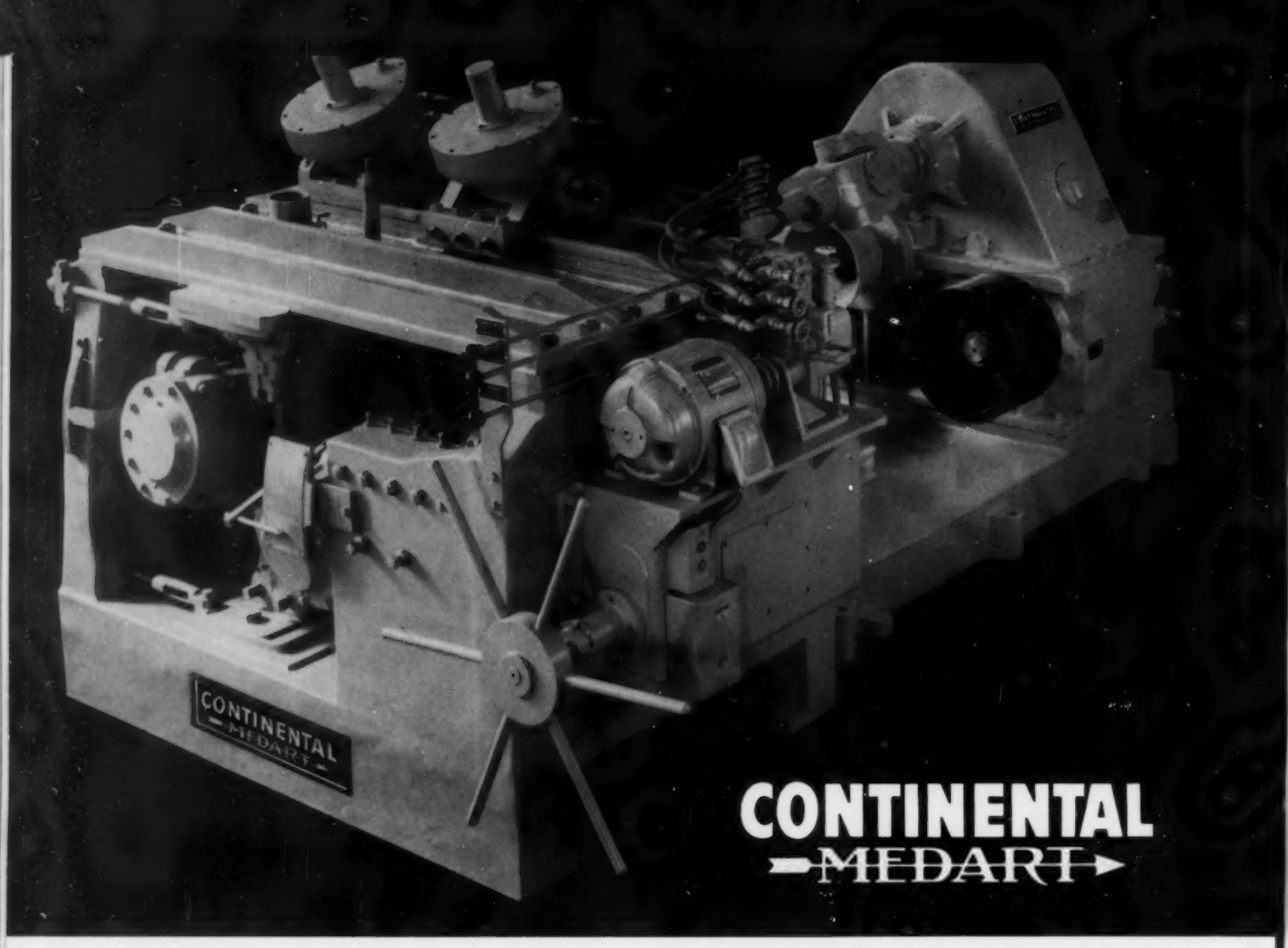
Precision hot strip direct from ingots

This Continental 66-inch four-high Reversing Hot Strip Mill is designed for the production of precision-gage hot strip by direct reduction from the ingot in a continuous operation. This installation is suitable for production of all grades of steel. Mill size is 26″ x 49″ x 66″, driven by a reversing motor through a pinion stand, single motor drive. It also is equipped with motor driven screw-downs providing full range speed regulation and hydraulic roll balance. Continental's rolling mill installations include every step from initial engineering to satisfactory operations.

CONTINENTAL

Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
Plants at **East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.**
Copes-Vulcan Division**, Erie, Pa.**

CONTINENTAL
Foundry & Machine
Company



Input end of No. 3 Size 2-Roll Rotary, single motor type

Straightens, sizes and polishes round bars and tubing—*in a single high-speed operation*

that features new push-button roll adjustment

For quality of output, for speed and accuracy, and for production economy, the CONTINENTAL-Medart 2-Roll Rotary has become an industry standard for the straightening, sizing and polishing of bars, tubes and pipe. It is in a class by itself.

And here is why. The CONTINENTAL-Medart 2-Roll Rotary processes work pieces completely from end-to-end in long lengths or as short as 1". It produces an improved finish on hot rolled; imparts a *super-finish* on cold finished; straightens to within a few thousandths; corrects out-of-round and improves physical properties—all in one operation.

In this new and improved design, operation is continuous, uninterrupted. Feed through and discharge is entirely automatic. Setup time is cut down by unique push-button adjustment of roll angularity and pressure settings. Motors will reverse with material between rolls to permit additional passes for sizing and polishing. Throughput speeds up to 400 fpm and higher are attainable, depending upon the size, type and condition of material.

Built in ten different sizes to process rounds over the complete range from ⅛" to 10" diameter, the 2-Roll Rotary is now used in virtually every ferrous and non-ferrous mill on this continent. Why not have a CONTINENTAL-Medart representative show you what this equipment will do for you!

CONTINENTAL

Engineering and Sales Office. 220 Grant St., Pittsburgh 19, Pa.
***Plants at* East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.**
***Copes-Vulcan Division*, Erie, Pa.**

CONTINENTAL
Foundry & Machine Company

TIMKEN® TQIT bearings speed roll removal at Detroit Steel's new Portsmouth mill

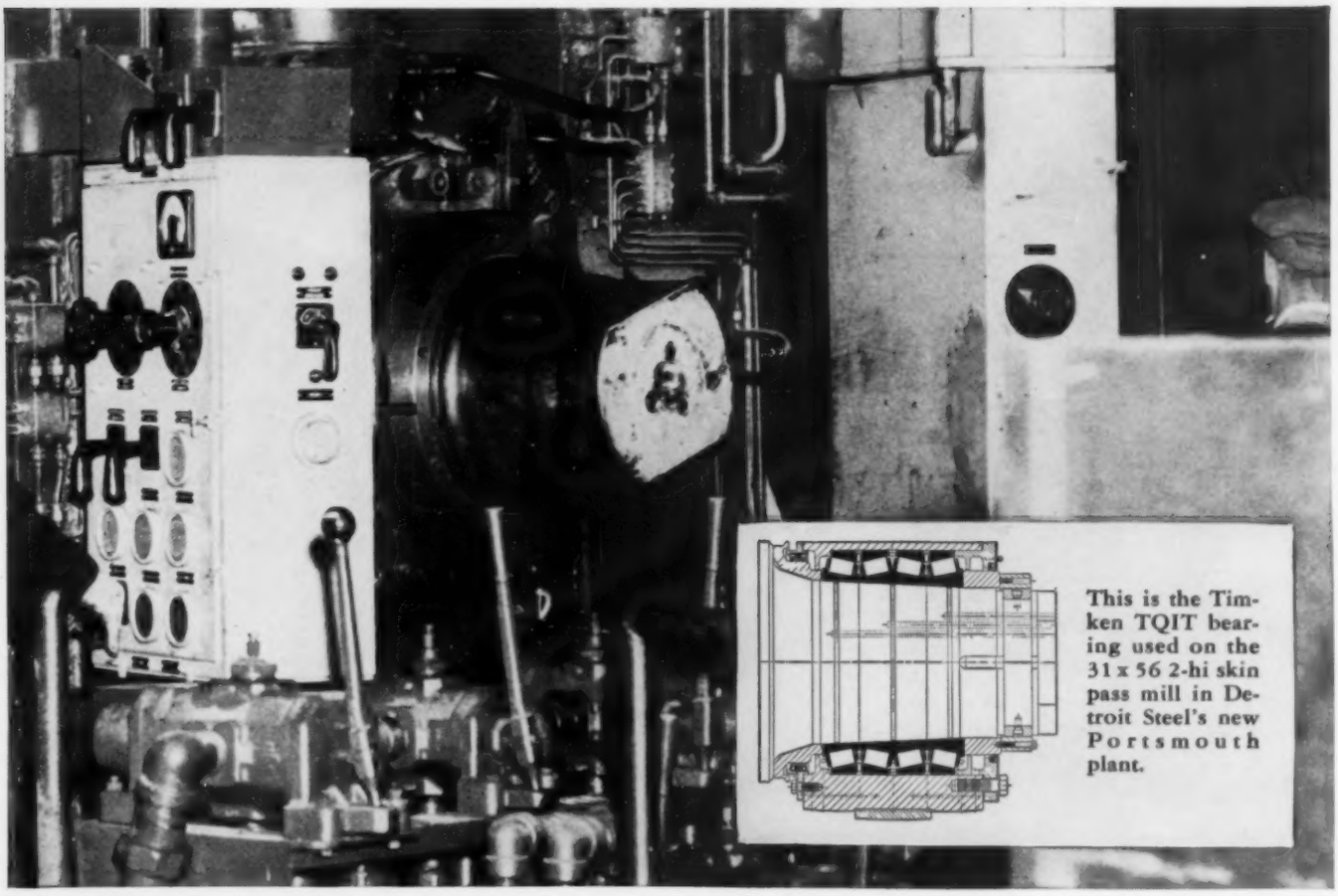
INSTALLED on this 31 x 56 2-hi skin pass mill at Detroit Steel's Portsmouth plant, are the new Timken® 4-row tapered bore, tapered roller bearings. They have interference fit. Yet they save considerable time on roll changes. By expanding their cones hydraulically, you can remove these Timken TQIT bearings from the roll neck quickly and easily.

The interference fit cones provide greater stability between the cone and neck, plus better load distribution. Excessive scuffing and neck wear are eliminated on high-speed mills like this one. And Timken TQIT bearings cut neck stress and deflections because they permit improved fillet contours and larger necks.

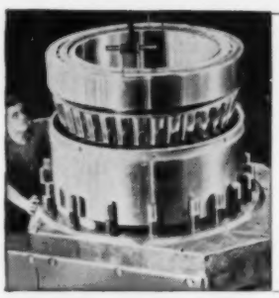
Like other Timken roll neck bearings, Timken TQIT bearings permit maximum roll neck size and greater mill rigidity. They also eliminate the need for special thrust bearings, make possible higher mill speeds. In addition, they allow starting and stopping of this skin pass mill without loss of steel.

To get these advantages in the equipment you build or buy, always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



This is the Timken TQIT bearing used on the 31 x 56 2-hi skin pass mill in Detroit Steel's new Portsmouth plant.



ROLL NECK BEARING ENGINEERING SERVICE

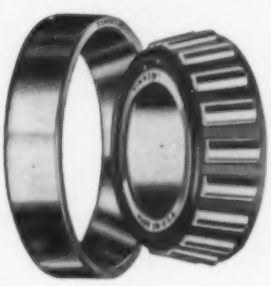
Our field and service engineers have had years of experience with problems of roll neck bearing design and operation. They'll help you select bearings and design mountings.

Only Timken tapered roller bearings have these advantages: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. nickel-rich Timken alloy steels.

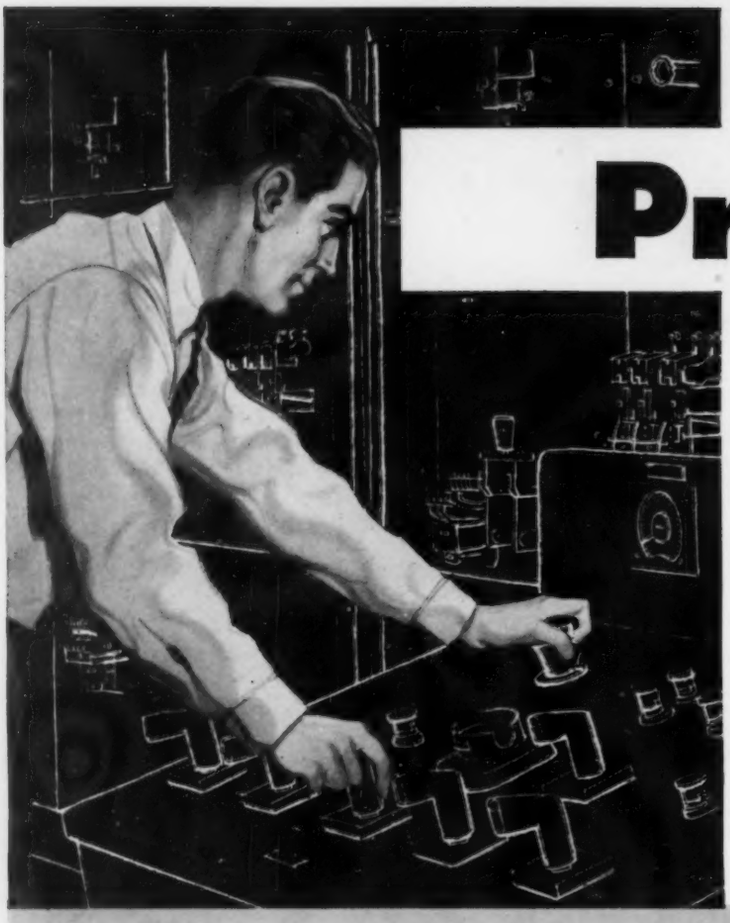
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬭ AND THRUST →⬭← LOADS OR ANY COMBINATION →⊕←



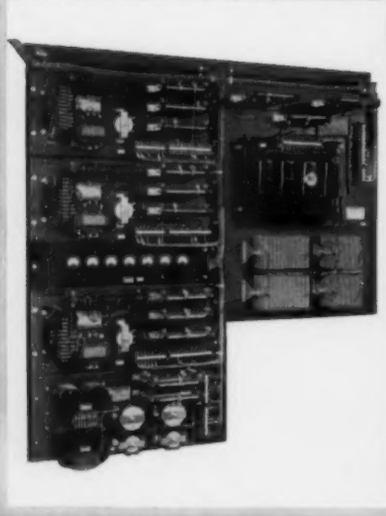
ALLIS-Processing

Allis-Chalmers constant potential and variable voltage systems are providing dependable precision control in many of the nation's largest mills.

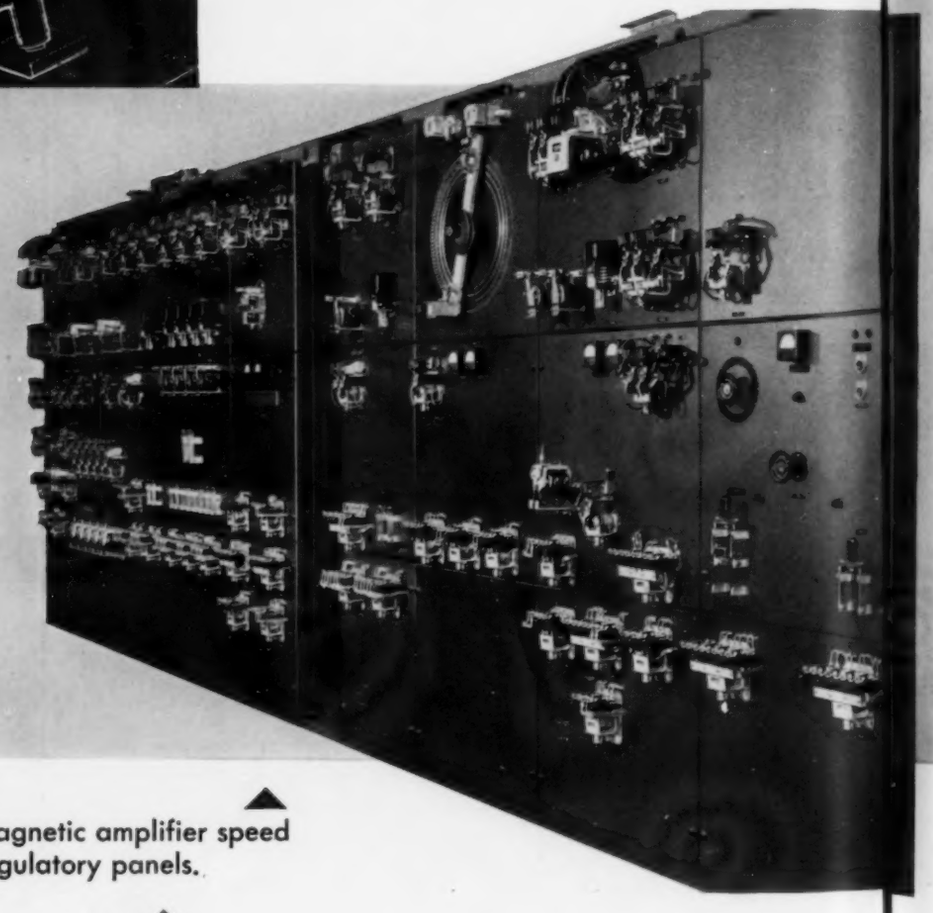
When you modernize

to meet the double challenge of a growing market and heavy competition, take advantage of Allis-Chalmers experience. See your nearby representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-4659



▲ Variable voltage control board for 39-inch continuous annealing line.

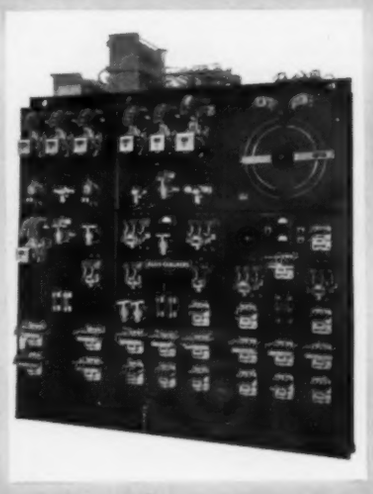


▲ Magnetic amplifier speed regulatory panels.

A-C ALLIS-CHALMERS

ALLIS-

CHALMERS
Line Control



Entry section control board for pickle line.

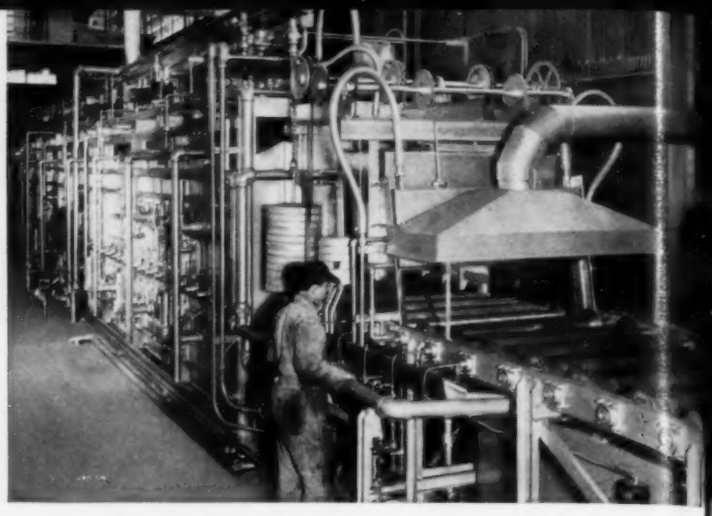
Delivery section control board.

Delivery end operator's desk, stainless steel top.

Riveter's cabinet, stainless steel front.

CHALMERS

continuous processing

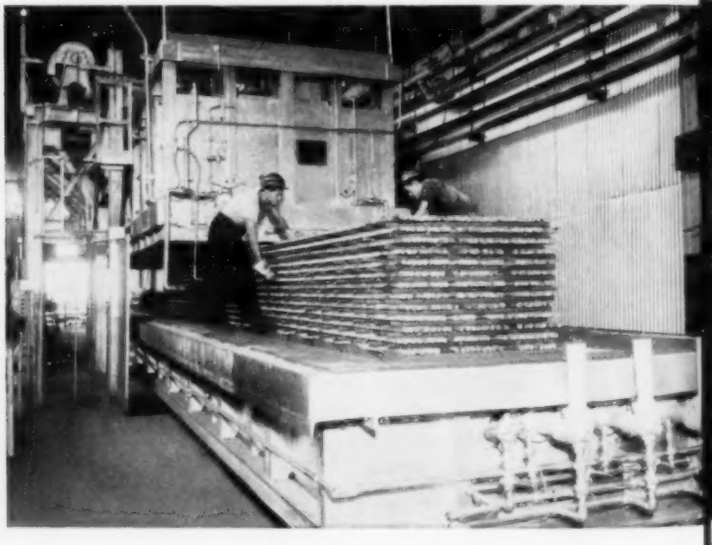


'Surface' roller hearth furnace for continuous carbon restoration-annealing of bars and coils.

'Surface' atmosphere equipment

'Surface' lift cover car bottom furnace used for batch carbon restoration-annealing of bar stock.

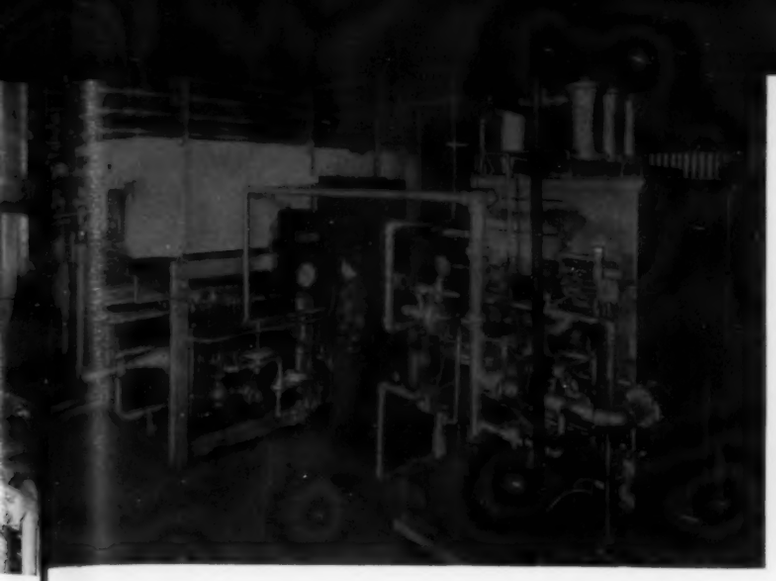
batch processing



Here are a couple of graphic reminders that Surface Combustion atmosphere equipment helps meet today's demands for top quality steel.

These cases repeat a familiar story in the steel industry: a steel processor wants to improve the metallurgical qualities of his stock—'Surface' equipment meets, and frequently exceeds, his specifications.

In your current program for improving the marketability of your products, look to 'Surface' to provide the right atmosphere for easier sales.

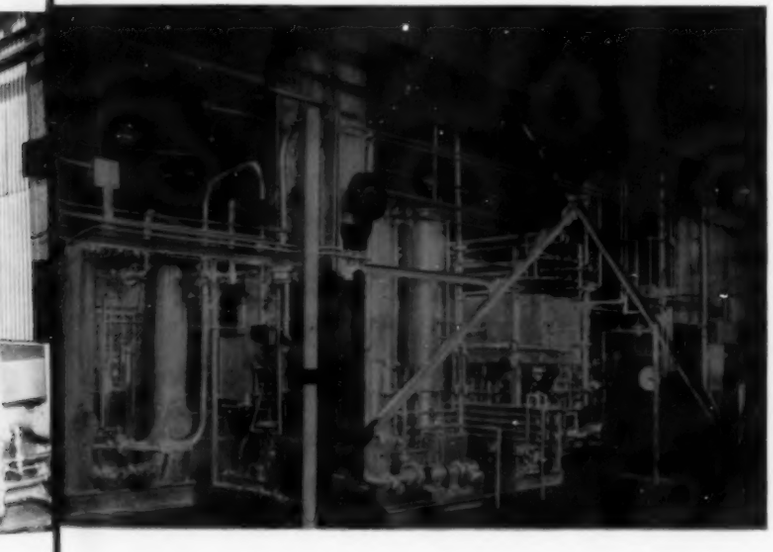


'Surface' atmosphere generators for this installation. RX unit in the foreground, NX unit in the background.

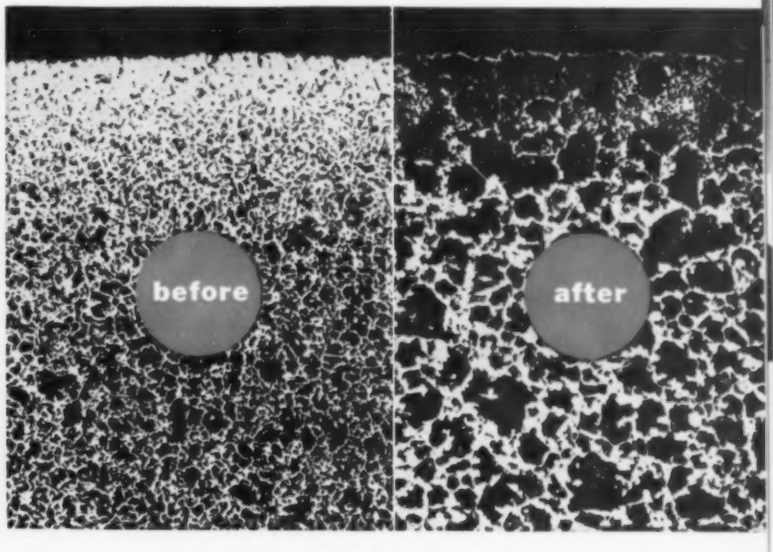
Before and after photomicrographs, Carbon steel AISI C1050. The results: carbon restored to the decarburized skin; steel which reduces the customer's machining costs, eliminates rejects.

makes steel easier to sell

'Surface' atmosphere generators next to the furnace. NX generators and coolers in the foreground, RX generator and dew point recorder in the background.



Before and after photomicrographs, C-1045, 1 1/16" round, coarse grain, 75x, 4% Nital etch. The results: carbon restored to the decarburized skin; steel that sells and opens new markets for the processor.



Surface
STEEL MILL FURNACES

SURFACE COMBUSTION CORPORATION · TOLEDO 1, OHIO

How to spend less for expendables

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Foundation of this new plan is your Honeywell Supplies Man. He is trained in the Honeywell factory and has a broad and thorough knowledge of instrumentation. A full-time supplies specialist, your HSM gives you personalized, expert service.

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1. ***Survey plant***—Your Honeywell Supplies Man checks annual consumption of each supply item in your plant and establishes minimum inventory needs.

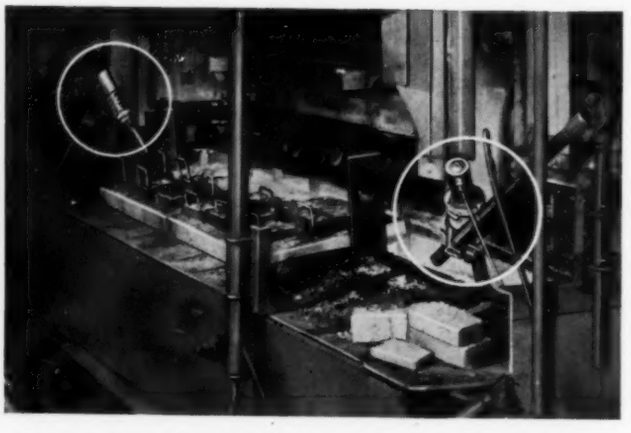
2. ***Detail requirements***—He then shows you what you can expect to purchase during the coming year to keep adequate stocks on your shelves.

3. ***Assist in selection***—He keeps you up to date on newest developments, and recommends specific types of equipment wherever your present buying can be improved.

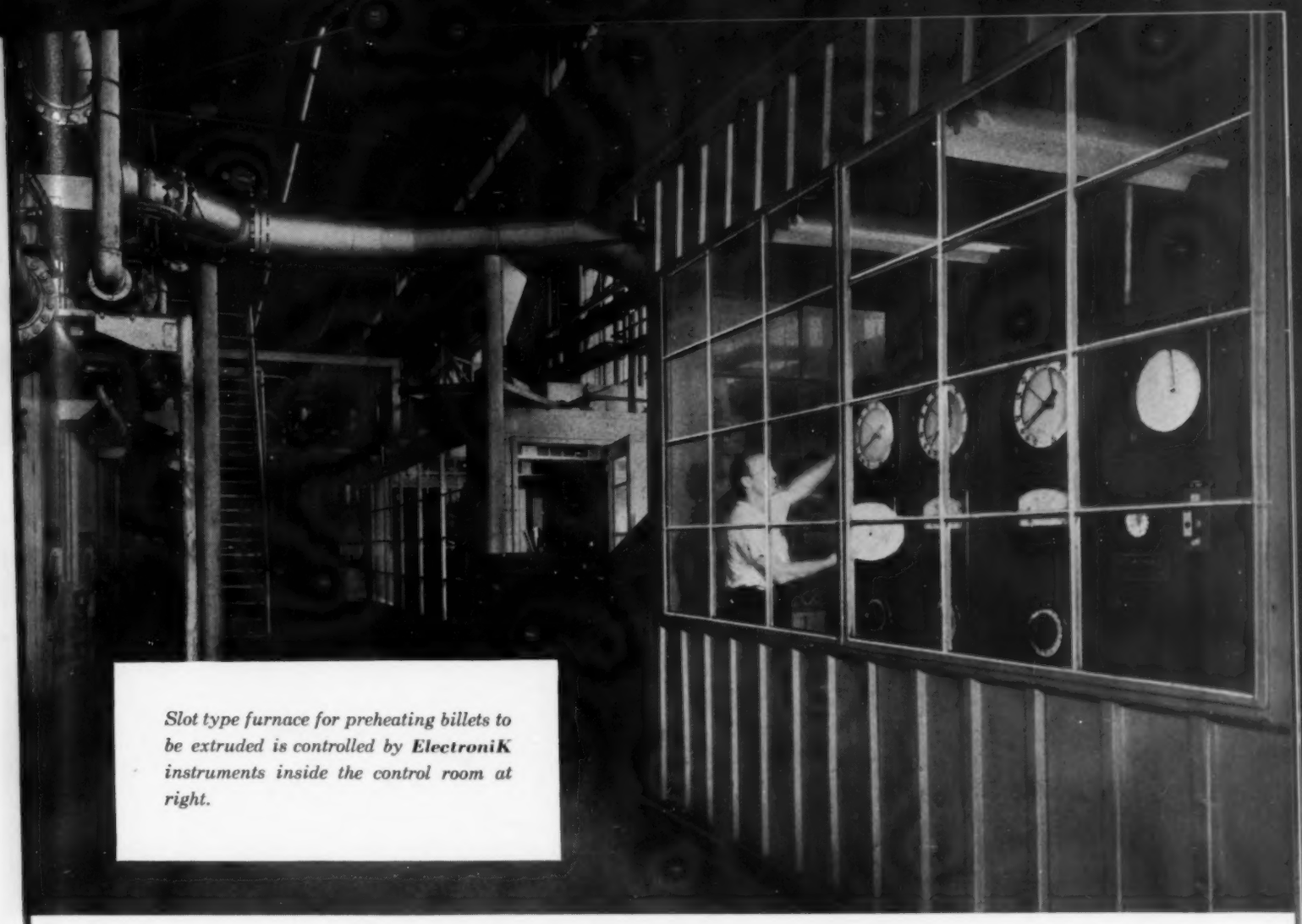
4. ***Estimate savings***—Next, he prepares a blanket annual order, grouping like items to get the biggest quantity discount. Savings may run as high as 50%.

5. ***Schedule deliveries***—Finally, he arranges a regular delivery schedule that assures that you will always have adequate supplies on hand. Give your Honeywell Supplies Man a call. He's at your local Honeywell office . . . as near as your phone.

New process for extruding steel gets high precision



Temperatures in the salt bath furnaces are detected by ***Radiamatic*** *radiation-type elements, which sight at the bath safe from fumes and high temperatures.*



Slot type furnace for preheating billets to be extruded is controlled by ***ElectroniK*** *instruments inside the control room at right.*

preheat with *ElectroniK** control

A REVOLUTIONARY IDEA in steel production . . . hot extrusion of tubes and complex shapes . . . has now become a manufacturing reality at United States Steel's National Tube Division in Gary, Indiana. Called the Ugine-Sejournet process, it consists of forcing preheated billets through a die, using molten glass as a die lubricant.

For the process to work satisfactorily, billet temperature has to be exactly right. If it's too hot, the billet seizes in the die. If it's too cold, the billet may crack the die or may not extrude.

Preheating is accomplished in two steps. Billets first go through a gas-fired slot type furnace, which brings them up over 1800 F. Then they get final heating in an electric salt bath furnace, from which they are fed to the extruder at 2300 F.

ElectroniK instruments perform the vital job of holding accurate temperatures in both types of furnaces. Those for the gas-fired furnace control each of three heating zones, using *Radiamatic* elements to detect temperatures, and *Throttlor* pneumatic control to actuate the gas valves. Control for the salt baths uses thermocouple instruments during stand-by and heat-up . . . then transfers to *ElectroniK* instruments with *Radiamatic* detectors sighted into closed-end tubes in the baths. The overall result is that billets are heated quickly and economically to exactly the correct temperature for the critical extrusion process.

Instrumentation by Honeywell covers the full gamut of metal production processes . . . includes temperature, flow, fuel-air ratio and all other essential variables. For a discussion of your specific requirements, call your local Honeywell sales engineer . . . as near to you as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA: Write for Catalog 1531, "*ElectroniK* Controllers," and Catalog 9301, "*Radiamatic* Pyrometers."**

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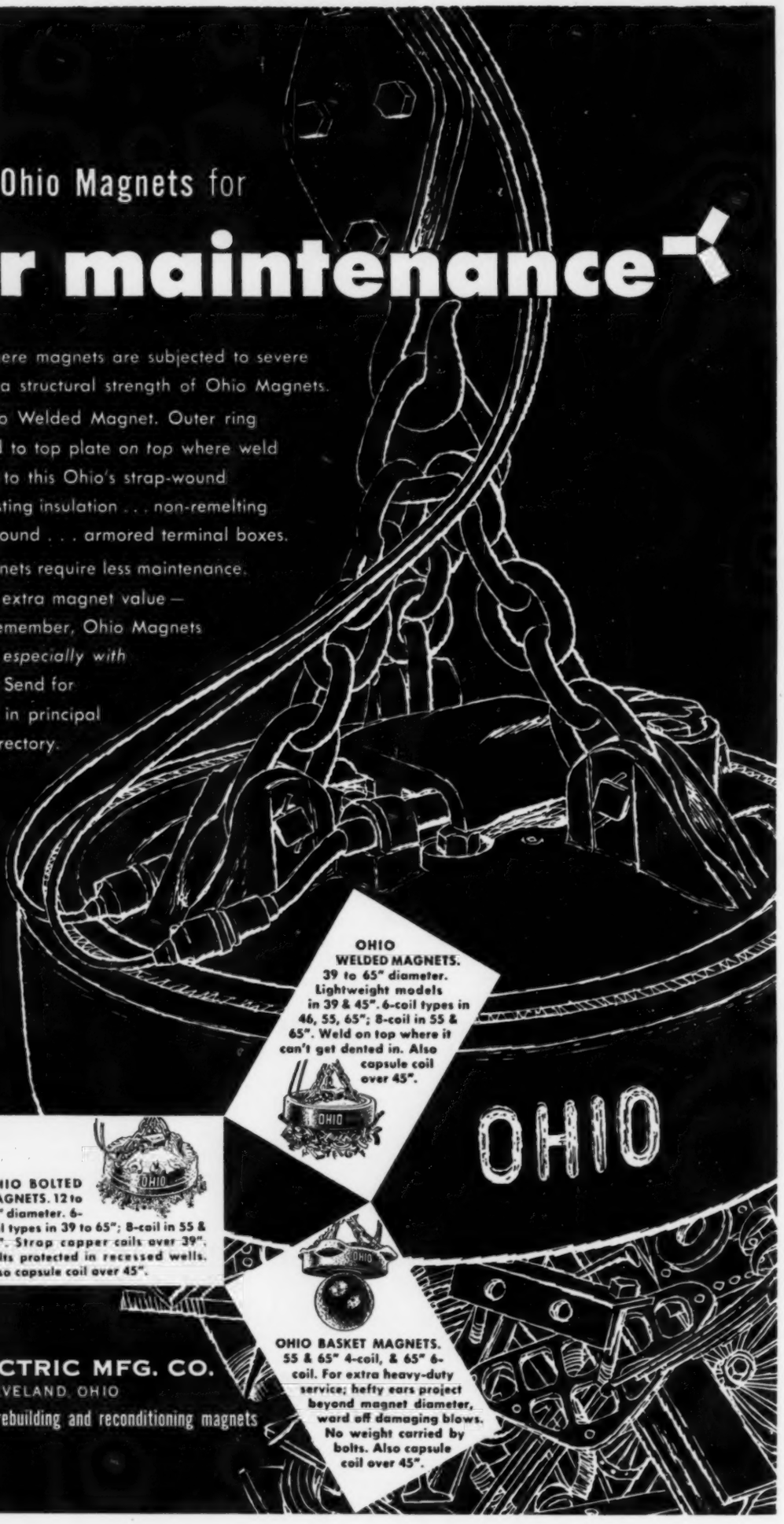

OHIO WELDED MAGNETS. 39 to 65" diameter. Lightweight models in 39 & 45". 6-coil types in 46, 55, 65"; 8-coil in 55 & 65". Weld on top where it can't get dented in. Also capsule coil over 45".

OHIO BOLTED MAGNETS. 12 to 65" diameter. 6-coil types in 39 to 65"; 8-coil in 55 & 65". Strap copper coils over 39". Bolts protected in recessed wells. Also capsule coil over 45".

OHIO BASKET MAGNETS. 55 & 65" 4-coil, & 65" 6-coil. For extra heavy-duty service; hefty ears project beyond magnet diameter, ward off damaging blows. No weight carried by bolts. Also capsule coil over 45".

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CHESTER BLAND *President*

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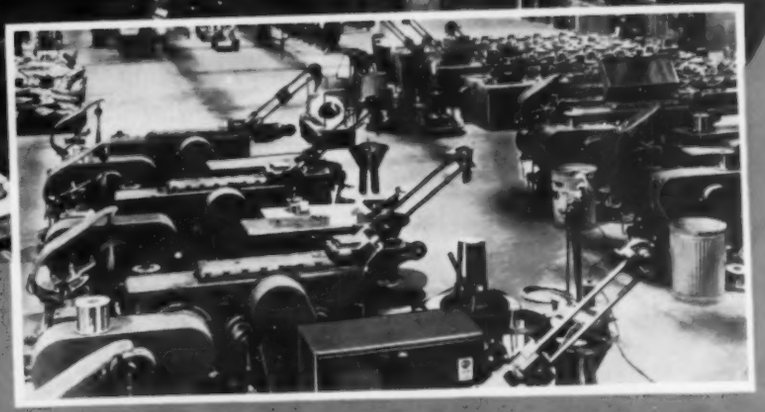

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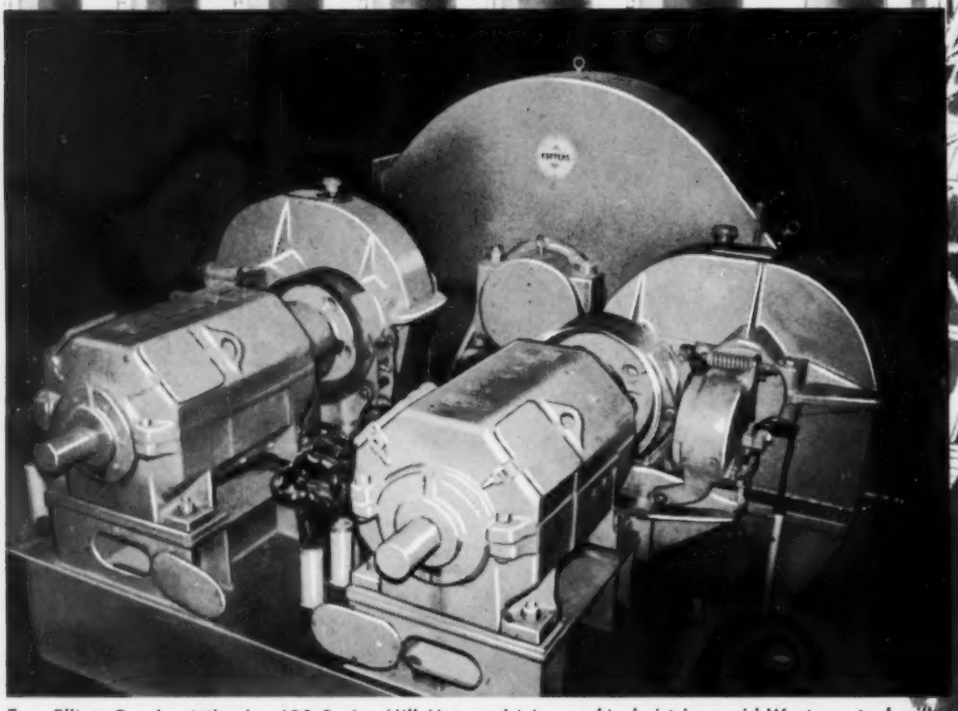
Giving a lift to steel mill skip hoists . . .



Two Elliott Crocker-Wheeler 600 Series Mill Motors driving a skip hoist in a mid-Western steel mi

ELLIOTT C-W MILL MOTORS

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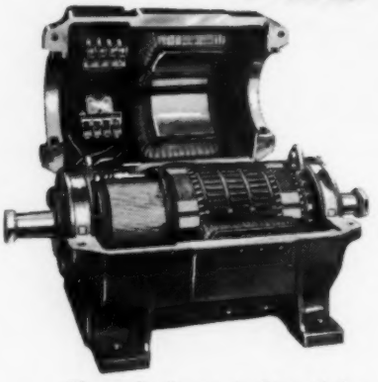
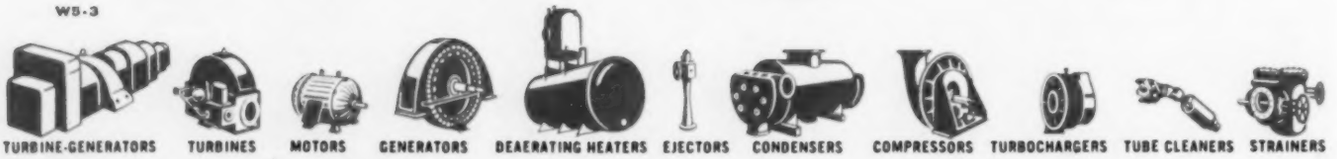


The split frame is hinged for easy access to all motor parts.

ELLIOTT Company

WB-3



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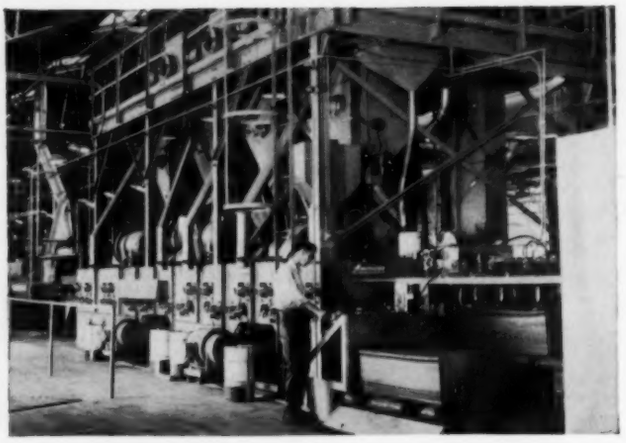
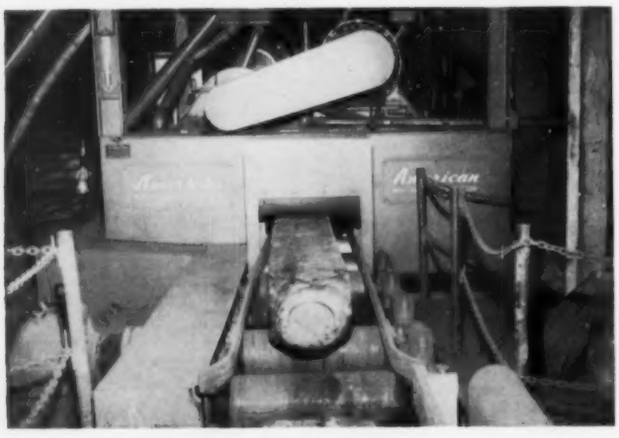
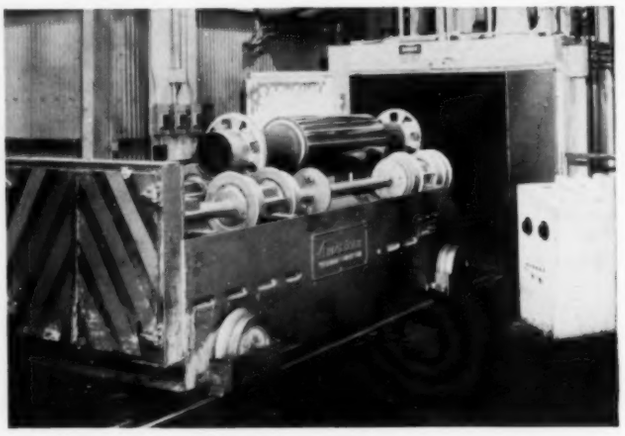
Descaling Strip at Allegheny Ludlum Steel Corp.



Descaling Sheet at Rheem Manufacturing Co.



Descaling Slabs, Billets at Atlas Steel, Ltd.



Etching Mill Rolls at U.S. Steel's Fairless Works

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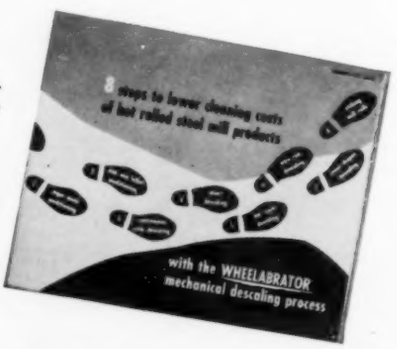
Write today for this fact-packed Bulletin, No. 864.



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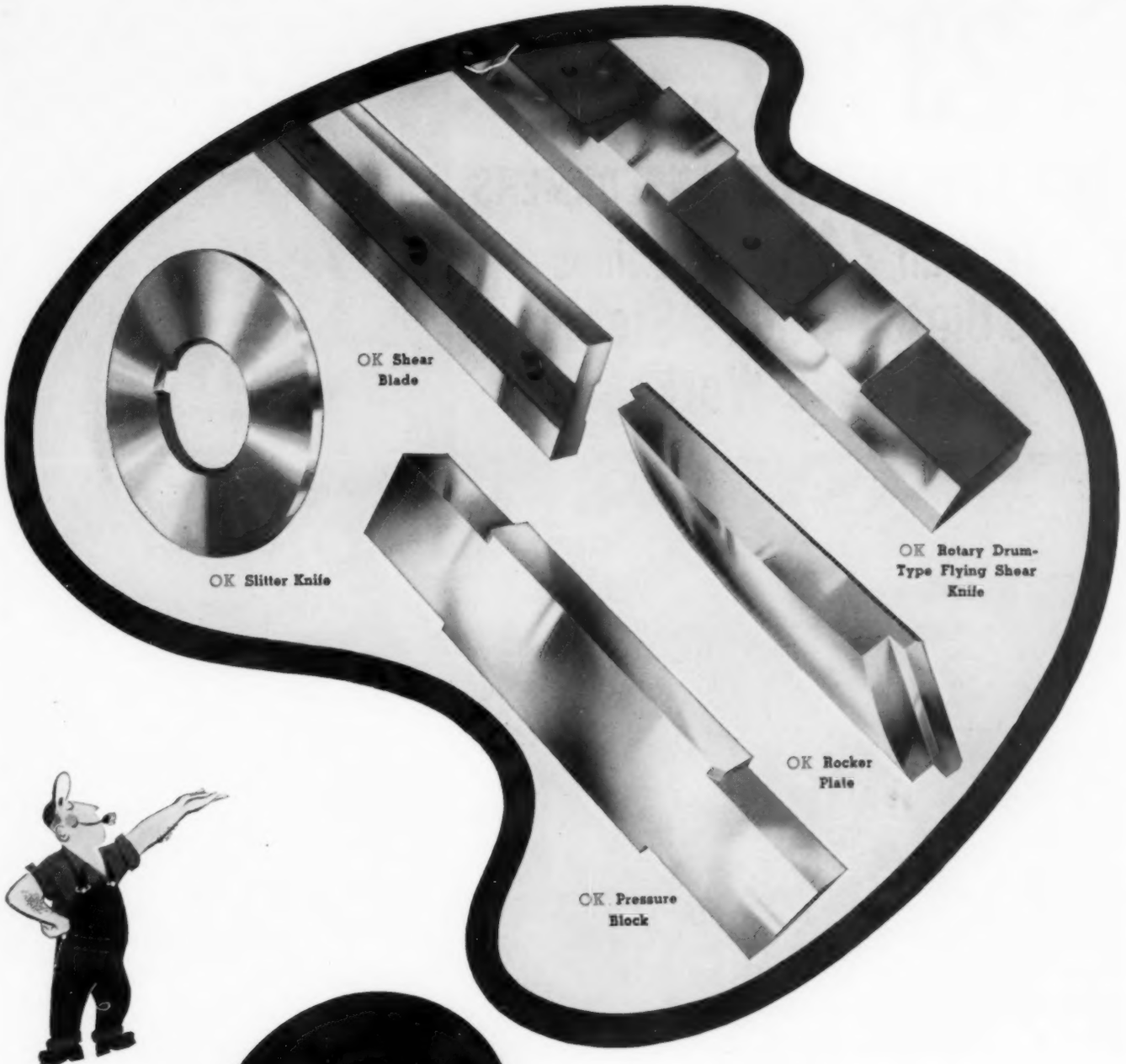

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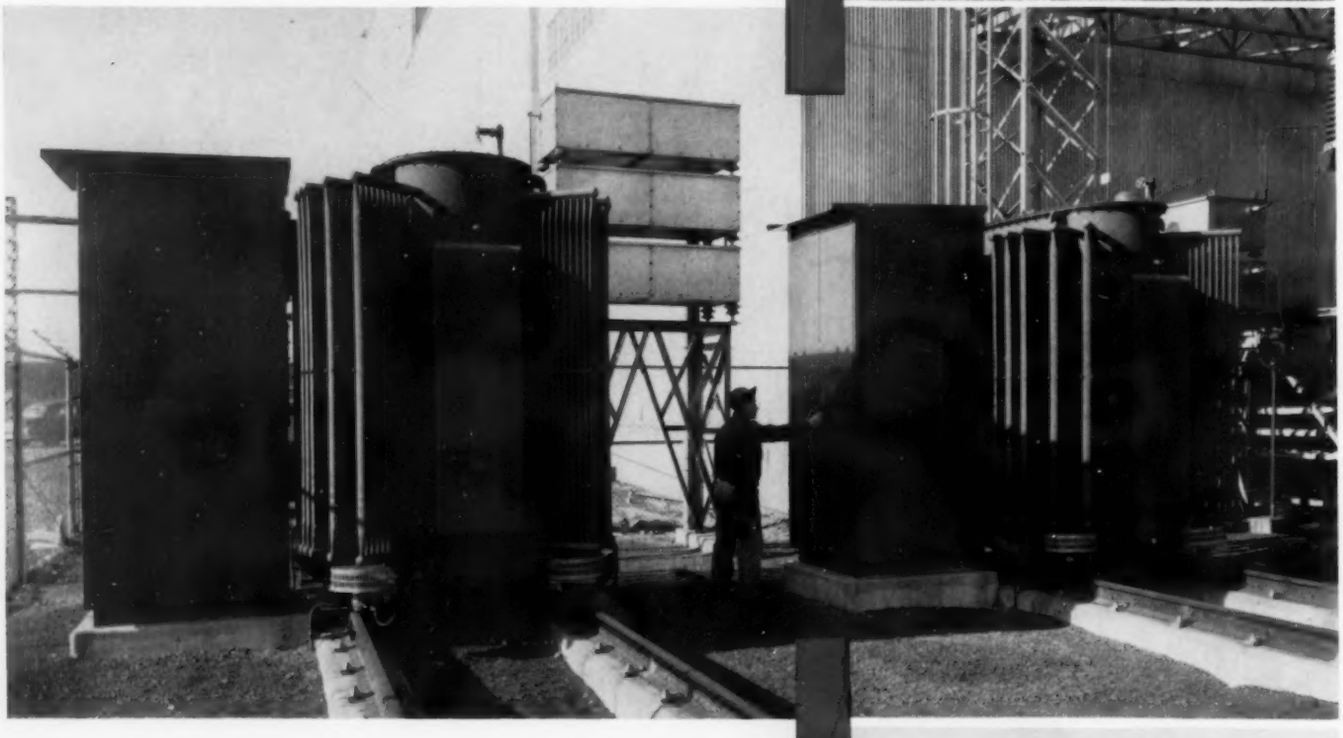
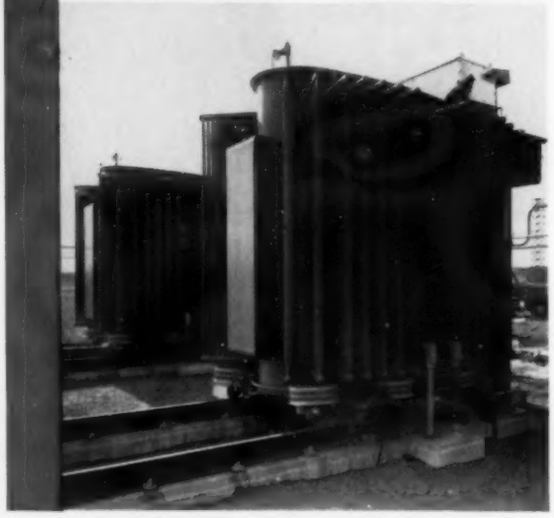
23 PENNSYLVANIA UNIT SUBSTATION TRANSFORMERS feed all 2400 volt lines at United States Steel's Fairless Works





19 — 2500 Kva and 4 — 3750 Kva Pennsylvania Transformers are supplying power at 2400 volts to operate open hearth furnaces, blast furnaces, hot and cold rolling mills, and coke ovens at the famous Fairless Works. Functioning as important components of I-T-E Unit Substations, these Pennsylvania Transformers assure an uninterrupted flow of power from the 13,800-volt power system to the 2400-volt distribution system.

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By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period December 28, 1954 through January 18, 1955 . . . .

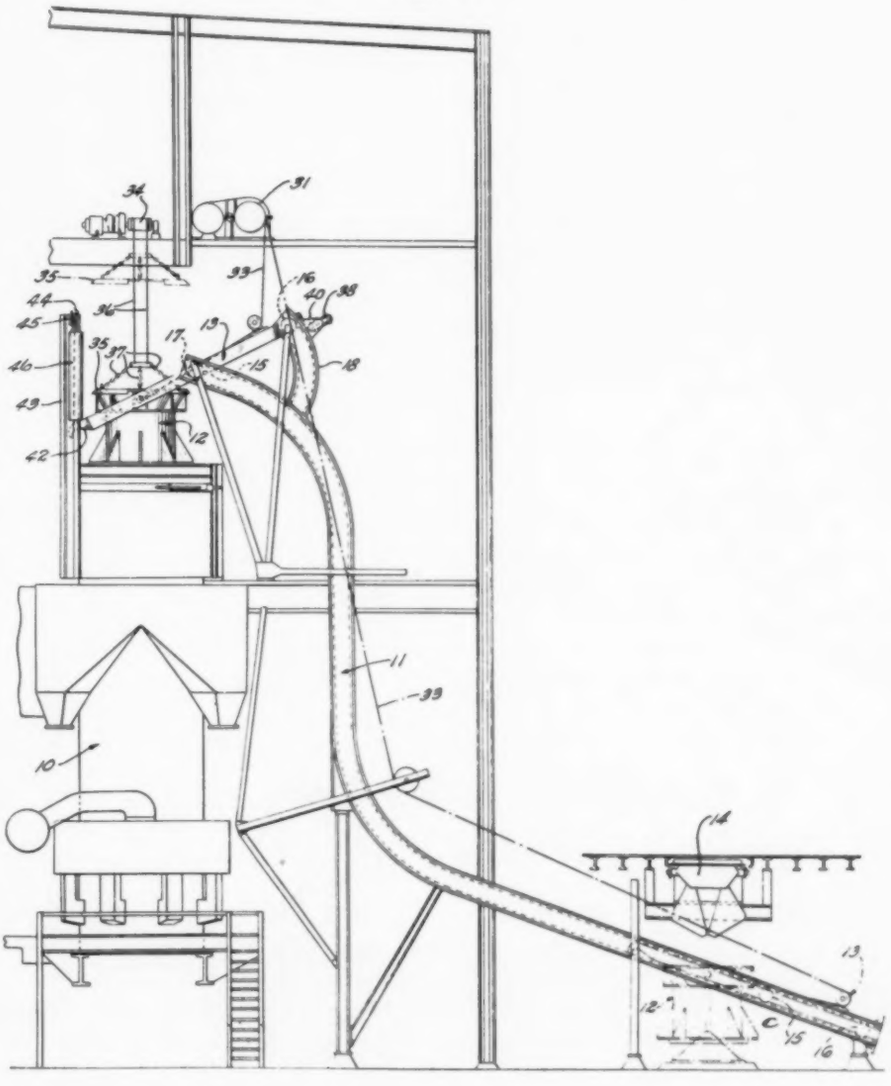
CUPOLA CHARGING APPARATUS

▲ U.S. 2,693,887, issued November 9, 1954 to Vernal P. Davel and assigned to Modern Equipment Co., describes a cupola charging apparatus in which the bottom closure of the bucket and the skip-carriage are actuated by the same source of power and by the same cables.

In Figure 1, the numeral 10 indicates a cupola of the sealed type, and the numeral 11 a skip-carriage track extending from a position above the cupola. The numeral 12 indicates a cupola charging bucket, and 13 a skip-carriage for supporting the bucket. The bucket is shown in charging position at the top of the cupola, and in loading position (in dotted lines) below a weigh hopper 14. The skip-carriage is provided with a pair of front wheels 15 midway of its length and a pair of rear wheels 16. The upper end of the track 11 is closed with a block 17 to limit the upward travel of the front skip-carriage wheels 15. An upstanding arc of track 18 branches from the track 11 and is in a position to be traversed by the rear skip-carriage wheels 16 while the front wheels 15 are abutting the block 17.

As shown in Figure 2, the open bottom of the bucket is equipped with a closure 21 in the form of a cone. The closed position of the cone is shown by solid lines, and open position by dot and dash lines. The bucket is provided with a pair of trunnions 25. A pair of sheaves 26 and 27 are mounted within the hollow partition 24. The skip carriage 13 is provided with sheaves 28. Mounted at each side of the rear end of the skip-carriage 13 is another sheave, and mounted on a support above this is a pair of reversible power driven cable drums 31. A cable 32 has one end connected to one end of the cross arm 23 and extends, over the sheave 26, through the trunnion 25, around the sheave 28, and around the sheave at the rear end of the skip carriage — the other end of the cable being connected to and wound around one of the cable drums 31. A second cable 33, corresponding to the cable 32, has one end connected to the other end of the arm 23 and extends around sheave 27, through the trunnion 25, around the adjacent sheave 28, and under the skip-carriage sheave — the other end of the cable 33 being connected to and wound around the other power driven cable drum 31. A cover-operating power driven cable drum 34

Figure 1



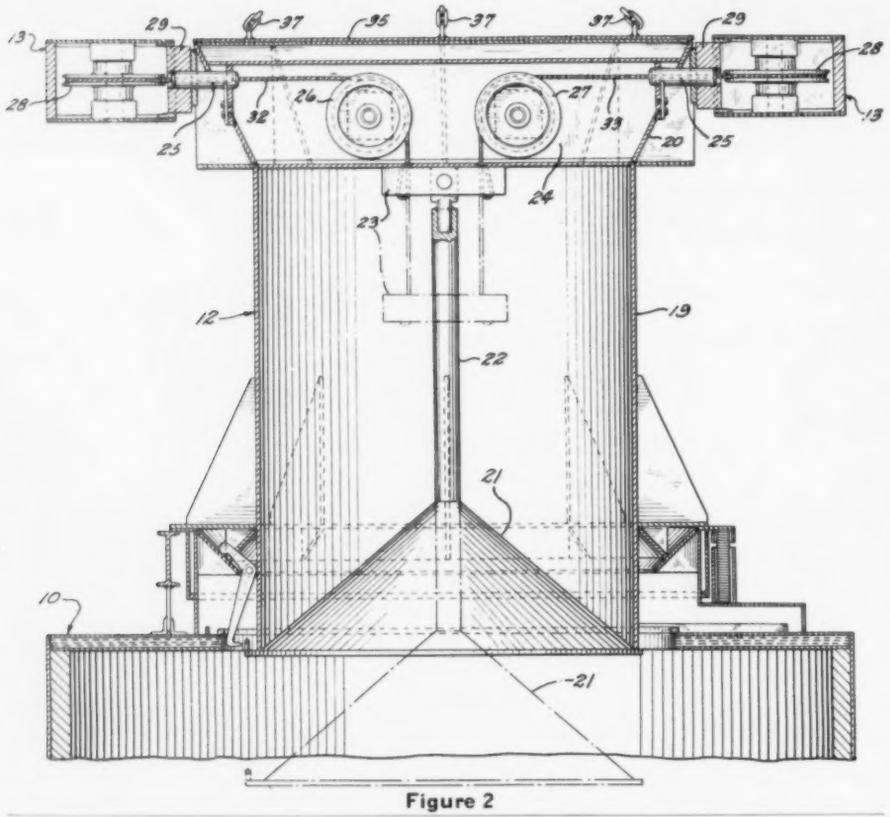


Figure 2

is mounted above the cupola 10, and the bucket cover 35 is connected to it by cables 36 and chains 37.

The same power driven cable drums 31 pull the carriage up the tracks, and are then rotated in a reverse direction to slacken the cables 32 and 33. This permits the bottom closure cone 21 to drop to the dotted position in Figure 2 to empty the bucket. The power driven cable drums 31 are again rotated in a direction to put tension on the cables 32 and 33 sufficiently to move the cone 21 to closed position. The bucket cover is then lifted to the dot-and-dash position of Figure 1 by means of the power driven cable drum 34, and the locking mechanism 38 is retracted to a position to clear the rear end of the skip-carriage. Then the power-driven cable drums 31 are rotated in reverse direction to slacken the cables 32 and 33 while the counterweights 46 swing the skip carriage wheels 16 down the arc section of track 18 and onto the main track 11. The skip-carriage and bucket then return to the loading station C by gravity.

APPARATUS FOR COILING ROLLED STRIP

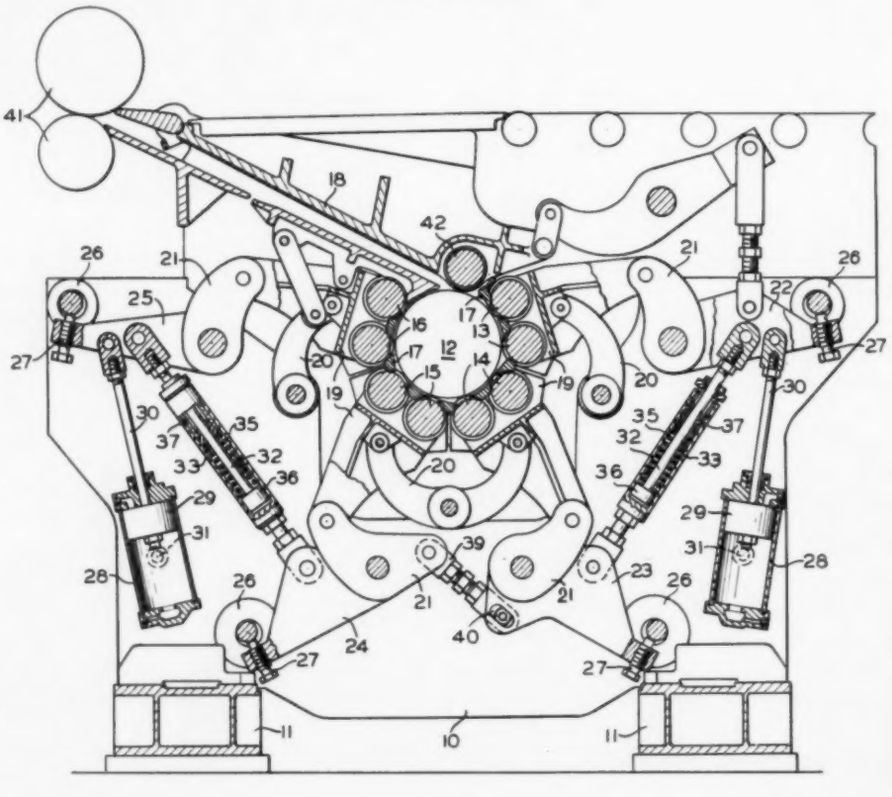
U.S. 2,693,919, issued November 9, 1954 to Theodor F. Wutscher, and assigned to The Loewy Engineering Co., Ltd., provides a coiler for hot rolled strip.

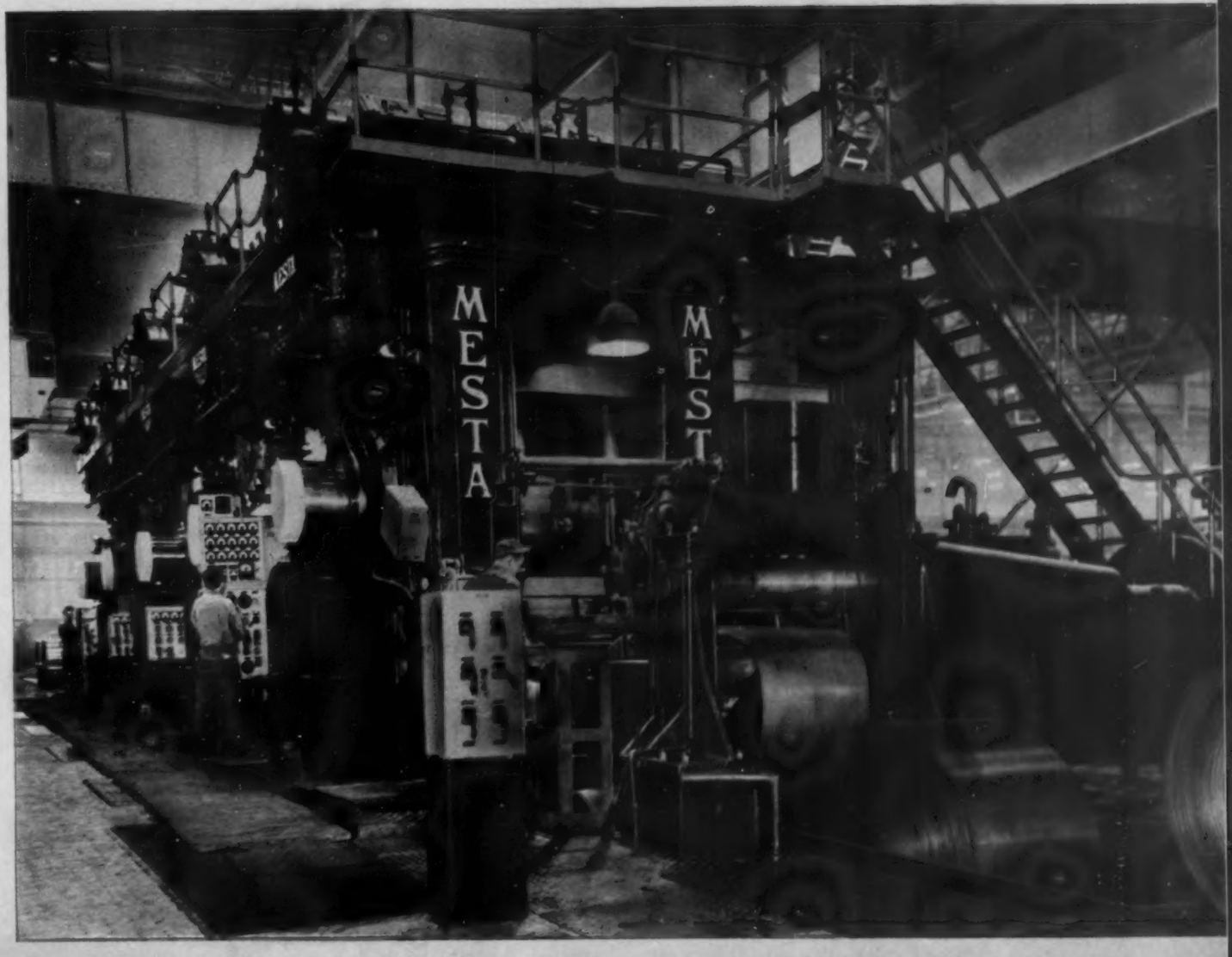
As shown in Figure 3, the coiler consists of a central mandrel 12 around which are disposed four forming rollers 13, 14, 15, and 16, with guide blocks 17 between adjacent rollers. Strip to be coiled enters through a guide piece 18 in a tangential direction. The forming rollers 13 and 16 are so mounted in the coiler frame that they can give way to the strip and recede radially as the strip passes them by. At the same time, they are subjected to inward pressure so as to produce the necessary tension in the strip in order to obtain a tightly wound coil.

Each pair of forming rollers is mounted on a separate carrier 19, each of which is connected by means of two curved links 20 and 21 to the housing and to one of four arms 22, 23, 24, and 25. A rocking movement of any arm about its pivot point results in a radial movement of the forming rollers. Pistons 29 have rods 30 which are pivoted to the arms 22 and 25, the cylinders 28 being pivoted to the housing 10 so as to allow rods 30 to follow the rocking movement of the arms 22 and 25. The interconnections between arms 22 and 23 and between 24 and 25 contain a coiled spring which permits limited relative movement between these rollers, while at the same time ensuring the transmission of radial pressure to the rollers. The interconnection between arms 23 and 24 has an element with a limited amount of lost-motion so that limited relative movement between rollers 14 and 15 is possible.

This arrangement enables the rollers 13 and 15 to recede when giving way to the strip without at the same

Figure 3





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Designers and Builders of Complete Steel Plants

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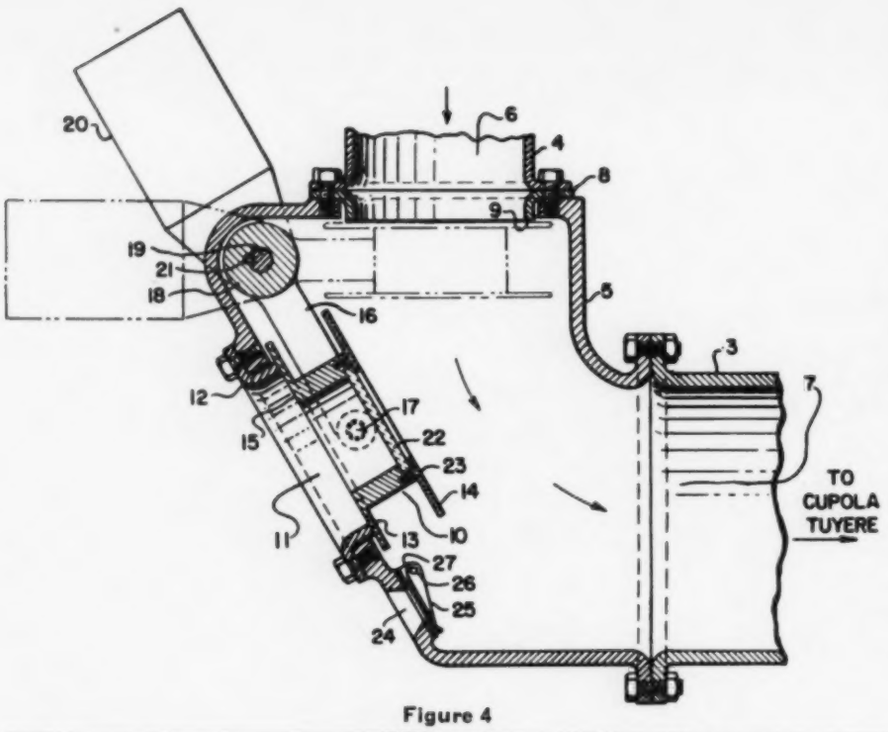


Figure 4

time compelling rollers 14 and 16 to carry out a corresponding radial movement. At the same time, the springs 35 ensure that full radial pressure is maintained on all the rollers.

IMPROVED TUYERE ELBOW FOR CUPOLAS

In U.S. 2,699,796, issued January 18, 1955 to Aubrey J. Grindle and Donald R. Killmer, Jr., and assigned to Grindle Corp., a tuyeré elbow is described which is suitable for use with a cupola, and which contains an automatic gas check valve.

The elbow is shown in Figure 4. The tuyere elbow-housing 5 is provided with a forced air inlet 6, an auxiliary natural draft air inlet opening 11, and a movable pivoted check valve 10 which can seat against either of the air openings.

When the cupola is in operation, an air stream is continuously fed down through the inlet 6 and out to the cupola tuyere. The valve 10 is closed against the auxiliary air inlet by the air pressure in the elbow. When the air supply to the wind box and inlet 6 is stopped, the pressure is taken off the valve 10, and it is moved upward by the counterweight 20, seating against the inlet port 6 (as shown in dotted lines). Thus, any back draft of gases from the cupola tuyere is prevented from passing into the windbox or cupola blower.

PICKLING PROCESS

In U.S. 2,700,004, issued January 18, 1955 to Clark O. Miller, and assigned to Cleveland Industrial Research, Inc., ferrous metals are pickled with ammonium acid sulphate. The spent liquor contains ferrous ammonium sulphate. After cooling, it is treated with ammonium hydroxide, resulting in the partial precipitation of the iron as a green gelatinous mass of ferrous hydroxide, which is difficult to filter. The slurry so produced is then oxidized by blowing with air, converting the iron to a magnetic iron oxide precipitate, which is readily filtered. The clear solution contains ammonium sulphate. Upon concentration by evaporation, crystals of ammonium sulphate are obtained. These are converted to ammonium acid sulphate by driving off ammonia by heating. Both the ammonium acid sulphate and the ammonia are then re-used in the process.

MANDREL CHANGING APPARATUS

In operating seamless tubing mills, the piercing mandrel must be changed after each billet has been pierced and must be thoroughly cooled before it can be reused. It is customary to employ three or more mandrels for each mill, one of which is in use while the others are cooling. Usually mandrels are changed manually, which is a fatiguing operation, particularly for larger sizes of mandrels.

In U. S. 2,699,697, issued January 18, 1955 to John W. Kelso and assigned to United States Steel Corp., an apparatus is provided for mechanically handling and changing mandrels, which can be installed on existing mills without further altering the mill or mandrel structure.

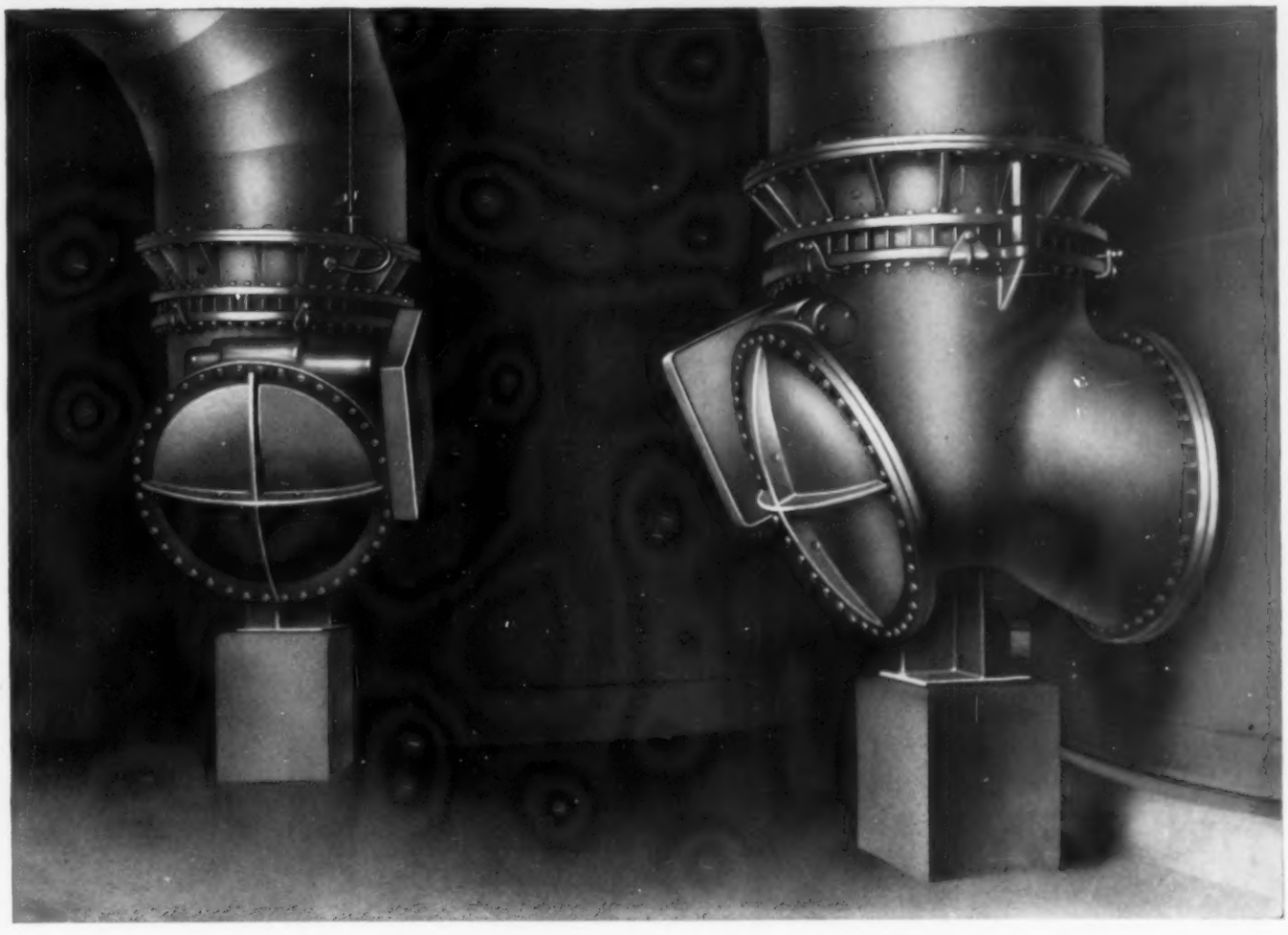
HOT TOP CONDITIONING EQUIPMENT

U.S. 2,697,860, issued December 28, 1954 to Benjamin F. Anthony, and assigned to The Ferro Engineering Co., describes a complete system for conditioning hot tops.

The invention provides "assembly-line" equipment on which the hot top travels while the various steps are carried out to invert the hot tops, clean them, apply the bottom rings, wiper strips and wire clips, patch any holes in the linings, apply patching material to the joints between lining blocks and between the latter and the bottom ring, apply slurry to the surfaces of the linings, transport them through a drying zone, and turn them over again so as to be presented right side up for the crane to remove them and place them in waiting ingot molds.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,697,869	12/28/54	Process for making aluminum coated ferrous sheet	Armco Steel Corp.
2,698,089	12/28/54	Apparatus for testing the high density ore content of a crude ore sample	Inter-State Iron Co.
2,698,229	12/28/54	Smelting of metal oxides	Quebec Metallurgical Industries Ltd.
2,698,467	1/ 4/55	Continuous casting of metal	Valentine Tarquinee et al.
2,698,469	1/ 4/55	Method of preventing piping in ingot molds	The Falk Corp.
2,698,749	1/ 4/55	Apparatus for introducing magnesium into molten iron or steel	John M. Fishell
2,698,785	1/ 4/55	Age-hardening austenitic stainless steel	Armco Steel Corp.
2,698,813	1/ 4/55	Silver brazing chromium stainless steel	Allegheny Ludlum Steel Corp.
2,699,388	1/11/55	Method and apparatus for making sponge iron	Anaconda Copper Mining Co.
2,699,992	1/18/55	Alloy cast irons	Karl Spitz
2,700,006	1/18/55	Process for producing fine-grained highly oriented silicon steel	General Electric Co.



622 Freyn-Design Chimney Valves in Service...

No Replacements!

The impressive service record of the Freyn-Design Chimney Valve for hot blast stoves is the best proof of its reliability.

It is a mushroom valve of the angle type, in which a simple, positive counterweight mechanism, passing over dead center, locks the disc in open or closed position. The valve disc opens away from the water-cooled seat and, when in the open position, is out of the path of the stream of hot stack gases.

When the spherically-machined disc is closed, stove blast pressure automatically forces a tight, sure closure. The valve can be cycled in less than 30 seconds, and may be operated manually either at the valve or from a floor stand on the floor above. It can also be provided with a motor or compressed air operator.

Freyn-Design Chimney Valves—in both top and bottom discharge design, with and without cold blast connections—have been proved in 622 installations. None has ever been replaced.

Investigate the long-range reliability and economy of Freyn-Design Chimney Valves for your hot blast stoves. We'll be glad to provide you with complete design and cost information. Write or call today!

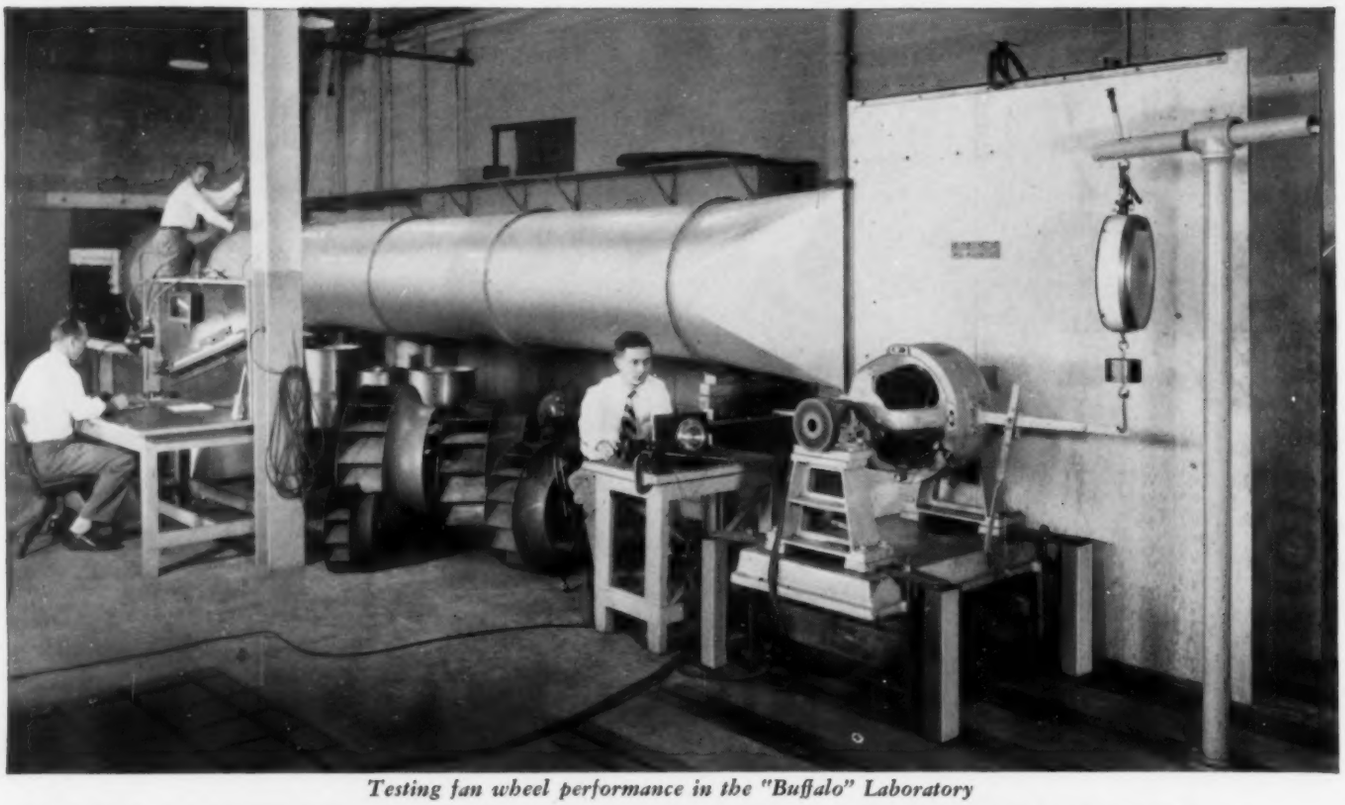
KOPPERS

KOPPERS COMPANY, INC.

Freyn Department

Engineering & Construction Division

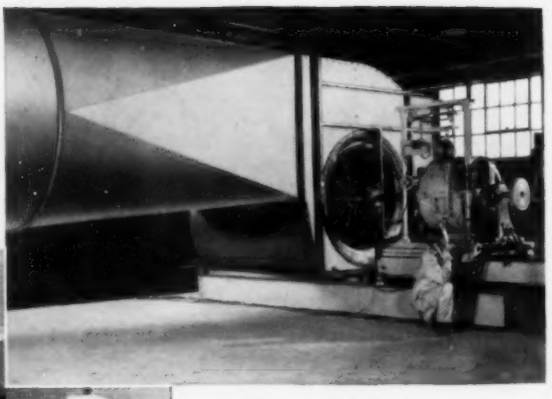
KOPPERS BUILDING • PITTSBURGH 19 *Associated with* Ashmore, Benson Pease & Co. Ltd., Stockton-on-Tees, ENGLAND; De Lattre & Frouard, Paris, FRANCE



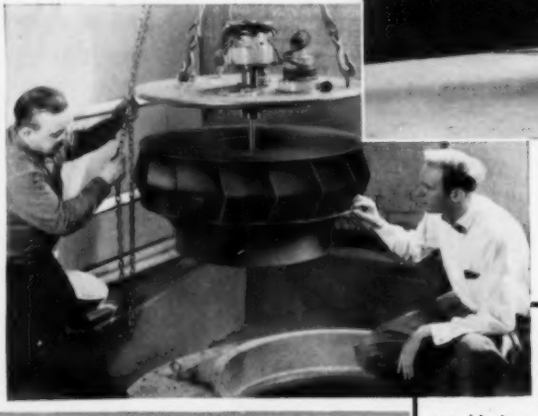
Testing fan wheel performance in the "Buffalo" Laboratory

WHY "BUFFALO" FANS PERFORM* AS SPECIFIED

What will this wheel design deliver at various static pressures? What are the horsepower requirements? Noise level? And what's the best housing? Endless testing like this in the "Buffalo" Laboratory — plus endless designing and redesigning — brought you the famous high-performance Type BL Limit-Load Ventilating Fan — and will continue to bring you the latest and finest in fans. You can expect this inbuilt performance whenever you order a "Buffalo" Centrifugal, axial flow or propeller fan.



WHERE WE TRY TO DESTROY WHEELS — the "Buffalo" vacuum test pit where wheels are revolved at many times their operating speeds to discover — and correct — any point of structural weakness. Further assurance of a better fan buy when you specify "Buffalo".



ALL TESTS in the complete "Buffalo" laboratory are conducted in strict accordance with the test code adopted jointly by NAFM and ASH&VE.

**Performance—another term for the "Buffalo" "Q" Factor—the built-in Quality which provides trouble-free satisfaction and long life.*

"Buffalo"

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING

FORCED DRAFT COOLING HEATING PRESSURE BLOWING

ALLIANCE SPECIAL 10-TON SOAKING PIT CRANE INSTALLATION
AT OHIO WORKS OF UNITED STATES STEEL CORPORATION

ENGINEERED AND BUILT BY *Alliance*

Illustrated here is a 10-ton low type, high lift soaking pit crane. Higher lift was required to handle longer ingots. The hoisting and tong mechanism is installed on the upper deck of a two-deck trolley for higher lift. This vertical construction also permits closer approaches to the ends of the crane for removing cold ingots from ingot cars for charging on one side of the building, and placing hot ingots in the chariot on the other. Consult Alliance Machine Company for any special or standard design crane.

Give Us The Runway And We'll Lift The World

THE *Alliance* MACHINE COMPANY

FOUNDED 1901

MAIN OFFICE: ALLIANCE, OHIO

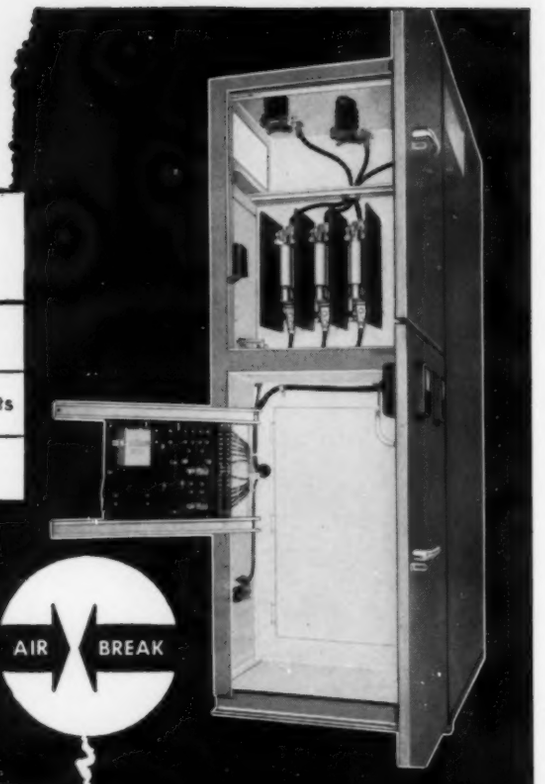
World's largest builders of world's largest cranes

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES
STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

AN EASY WAY TO SELECT HIGH INTERRUPTING CAPACITY STARTERS

50,000 KVA*	POWER FUSES		VALIMITOR	
2200-5000 volts	2300 Volts	4800 Volts	2300 Volts	4800 Volts
	150,000 kva	250,000 kva	unlimited kva bus	

* Certified



On Air-Break ZHA Starter, overload relay panel swings out. Opening of inner door gives access to motor terminals and rear of contactor.

YOUR BEST BUY FOR SHORT CIRCUIT PROTECTION

EC&M (2200-5000 VOLT) MOTOR STARTERS

EC&M Oil-Break Starter of VALIMITOR type has ZHS, 50,000 KVA Contactor mounted under oil in rear tank.

No matter how you figure it . . . high voltage motor starters, with adequate interrupting capacity, are your best investment.

Should a fault occur, vital drives are protected by clearing the circuit quickly. The need for extensive repairs or replacements has been minimized. Down-time is reduced. This results in lower costs.

Although short circuit values get greater as KVA capacities grow, EC&M's complete line of Motor Starters provides a wide range of selection to cover any requirement. They are available in Oil and Air-Break styles having interrupting capacity ratings shown above . . . note there are 3 ratings in both oil and air break.

The ceiling on the short circuit problem has been lifted. Be sure you have the information on this wide choice of EC&M Motor Starters for 2200-5000 volt motors.

Write for handy new catalog 6062 showing complete coverage of 2200-5000 volt motors.

THE ELECTRIC CONTROLLER & MFG. CO.
4498 LEE ROAD • CLEVELAND 28, OHIO

6072

Modern Steel Makers Maintain Control with RCA Industrial TV

Production records are being made through mill supervision by RCA Industrial TV... On an 80" mill that holds the world's record for hot strip, a camera over the mill and a TV screen on the control pulpit permit the operator to detect threats of pile-ups, or other troubles, before damage occurs. One pile-up on a strip mill can mean as much as 15 minutes of lost production time or 120 tons of steel... so it pays off handsomely to KNOW, not GUESS.

Many Uses. Other uses include RCA Industrial TV to observe furnace conditions, heat treating, charging, crane movement, and other hazardous or inaccessible operations... wherever it's important to *see* where you cannot *look.*

Direct-Observation Clarity. With RCA Industrial TV you attain the accuracy of direct observation without danger or inconvenience. You see a high-definition, high-contrast picture that's best for efficient centralized control, and all camera adjustments are conveniently made at the viewing monitor.

Survey Without Obligation. Let us make a survey of your Industrial TV requirements without obligation. RCA's practical Service Plan provides for service by experienced factory-trained engineers. Use coupon below for literature.

RCA CAMERA... compact, rugged, built to give reliable service under rough operating conditions. Uses the sensitive RCA-developed time-proved Vidicon tube, reducing weight to a minimum.

RCA MONITOR... shows stable, high-definition picture, assures accurate reproduction of fine details. For convenience and ease of operation, all controls for camera and TV are located on control monitor.

ACCESSORIES... include water-cooled camera lens, explosion-proof housing, panel-mounting monitor, camera switcher, industrialized auxiliary viewer, remote iris, remote focus, pan and tilt assembly and other field-proved equipment.

New Low Prices Now in Effect!

RADIO CORPORATION of AMERICA

CAMDEN, N. J.

In Canada: RCA VICTOR Company Limited, Montreal

Radio Corporation of America
Dept. R-188, Building 15-1, Camden, N. J.

Please send me latest brochure on use of RCA Industrial TV in steel mill operations.

Name.....Title.....

Company.....

Address.....

City.....Zone.....State.....

Facts on industry's most preferred motor brake

FACT:

Now . . . the only completely **self-adjusting** motor brake on the market

The new Westinghouse type SA (self-adjusting) d-c magnetic brake is the first and only brake on the market to completely eliminate time-consuming brake adjustments. It compensates for lining wear and wheel expansion—and *increases lining life 50%.*

And that's just one cost-cutting feature that makes the new SA the best design available. There are others equally important to your maintenance costs whether your application relates to cranes or hoists, turntables, lift bridges, screw-downs or other similar heavy-duty applications.

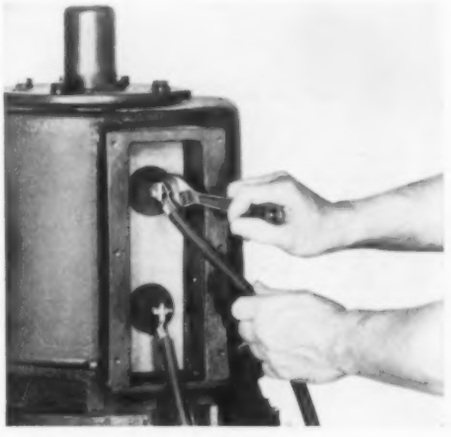
Get all the SA brake facts from your Westinghouse sales engineer—*The Man With The Facts.* J-21895

YOU CAN BE SURE...IF IT'S

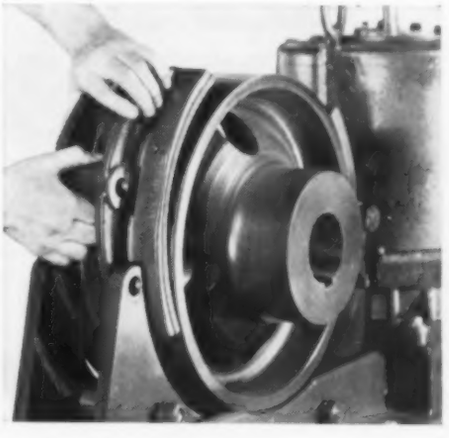
Westinghouse

Maintenance Facts

Dust-tight—weatherproof magnet housing is easily and quickly removed for coil accessibility. Coils can be repaired on the spot—no need to return them for factory repair.



Conduit box is cast integrally with housing—large enough for two-hand workability—can be rotated 120° for a right or left location depending on installation.



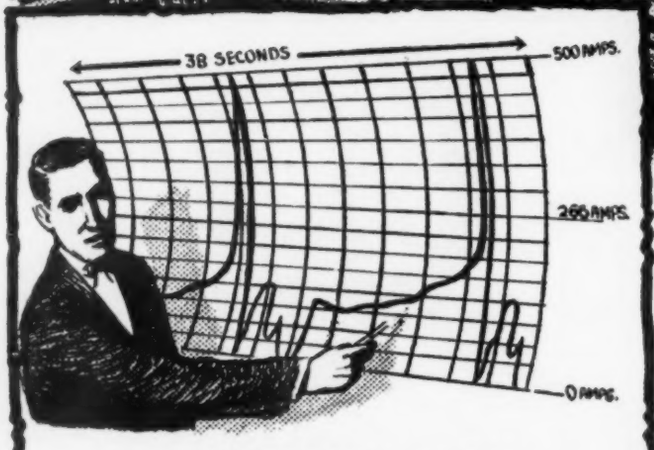
Brake shoes are interchangeable and can be quickly removed for lining replacement. Unique linkage design assures permanent self-alignment both horizontally and vertically with the motor shaft.

FACTS ABOUT Exide®

IRONCLAD® INDUSTRIAL TRUCK BATTERIES

NO MOVING JOB IMPOSSIBLE!

STEEP RAMPS, LONG HAULS, HEAVY LOADS... NO JOB IS IMPOSSIBLE WHEN ELECTRIC TRUCKS ARE POWERED WITH IRONCLADS. EXIDE MAKES BATTERIES WITH ADEQUATE CAPACITIES TO KEEP TRUCKS WORKING FULL-SHIFT...WITH NO LET-DOWN IN TRUCK POWER OR PERFORMANCE. USER COST RECORDS SHOW THAT EXIDE-IRONCLADS ARE YOUR BEST POWER BUY— AT ANY PRICE!



PORTRAIT OF AN EXIDE WORKING

IN JUST TWO MOVES AND 38 SECONDS A FORK TRUCK MAY DRAW ENERGY FROM ITS BATTERY IN THIS PATTERN, IN RESPONSE TO 44 SEPARATE CONTROLLER OPERATIONS. IN AN 8-HOUR SHIFT, 3000 SUCH DEMANDS MAY BE MADE. EXIDE-IRONCLADS ASSURE RAPID, ACCURATE HANDLING OF MATERIAL... THEY RESPOND INSTANTLY TO THESE RAPIDLY RECURRING DEMANDS FOR HIGH POWER FOR SHORT DURATIONS.

TUBES OF POWER WORK FOR YOU INSIDE AN IRONCLAD

SLOTTED TUBES INSIDE AN IRONCLAD KEEP ACTIVE MATERIAL IN FIRM CONTACT WITH CONDUCTING GRIDS OF THE POSITIVE PLATE...THIS GRID PROTECTION LENGHTENS THE LIFE OF THE BATTERY. SLOTTED TUBES EXPOSE MORE ACTIVE MATERIAL TO THE ELECTROLYTE... FOR GREATER POWER. FINE TUBE SLOTS HOLD MATERIAL IN CONTACT WITH GRID LONGER...RESULT, THE IRONCLAD'S ABILITY TO DO YOUR MATERIALS MOVING JOB FOR A LONGER PERIOD OF TIME. THAT IS WHY EXIDE-IRONCLADS ARE YOUR BEST INDUSTRIAL TRUCK BATTERY BUY— AT ANY PRICE!

LET EXIDE HELP SOLVE YOUR INDUSTRIAL TRUCK BATTERY PROBLEMS. ❶ CALL AN EXIDE SALES ENGINEER FOR FULL DETAILS. ❷ WRITE FOR FORM 1982, A MANUAL ON INSTALLING AND MAINTAINING MOTIVE POWER BATTERIES.

Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

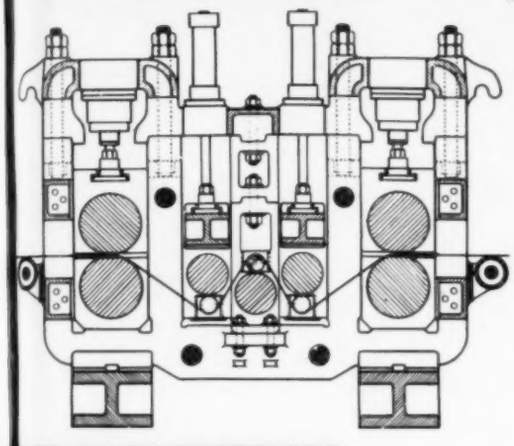
Y F&M TRIPLE SCALE BREAKER

Speeds Pickling with the New

"YOUNGSTOWN"

High Speed Continuous Strip Pickling Line

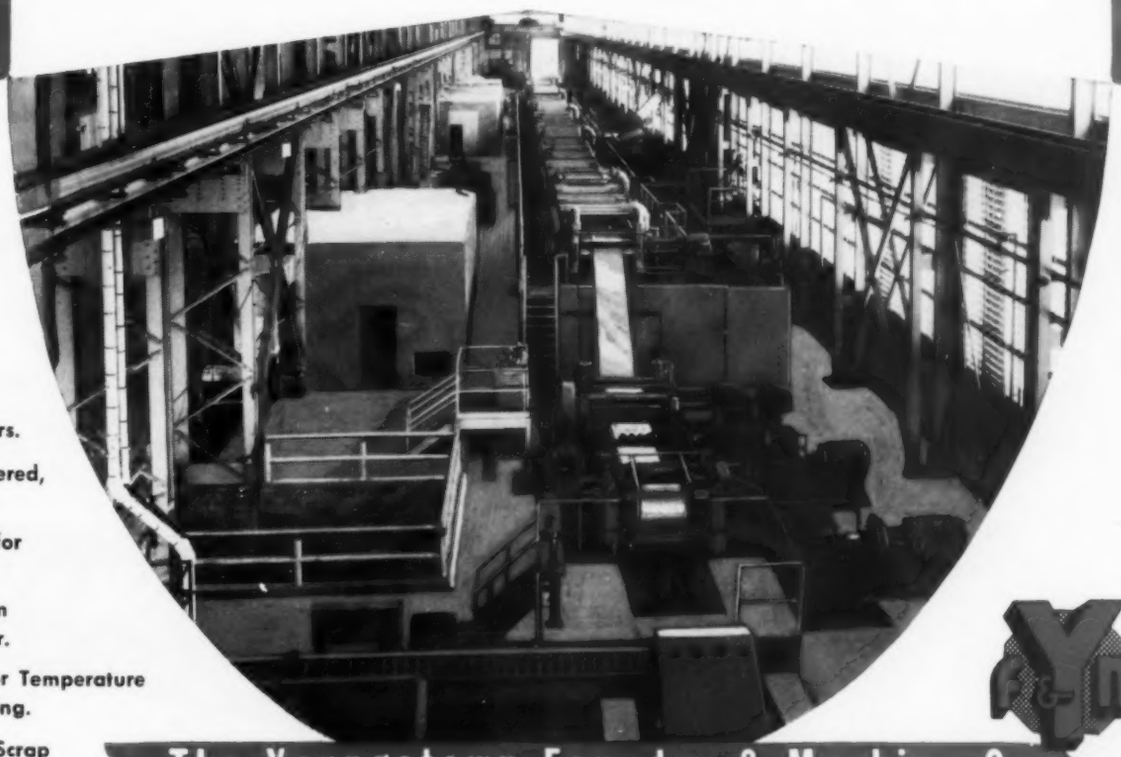
...Better Pickling with Less Acid and Lower Cost!



See our new, pull thru type, TRIPLE SCALE BREAKER, —a revolutionary improvement that eliminates the need for a Pinch Roll Stand in a modern Pickling Line. Investigate this and other new "YF&M" advantages. Whatever your pickling requirements,—complete new lines, revamping of existing lines, new tanks, rubber-covered rolls, Paralloy pinch rolls, any pickling line equipment,—get the benefit of our 70 years' experience. Consult "Youngstown" on how to speed up your pickling, cut acid consumption and make your operation more profitable.

features—

- Cone Type Payoff with Strip Opener.
- Triple Processor with Roller Leveller.
- Flash Welding and Mechanical Stitching.
- Pull-Thru Type Triple Scale Breaker.
- Single Cycle Up-Cut Shears.
- Heavy Duty Rubber Covered, Brick Lined Steel Tanks.
- Magnetic Loop Control for Acid Tanks.
- Fume Exhaust System —Roto Clone Scrubber.
- Automatic Control for Temperature and Acid Proportioning.
- Side Trimmer with Scrap Cutting or Balling
- Up-Coiler with Strip Oiling System.
- Entry and Exit Coil Conveyors.

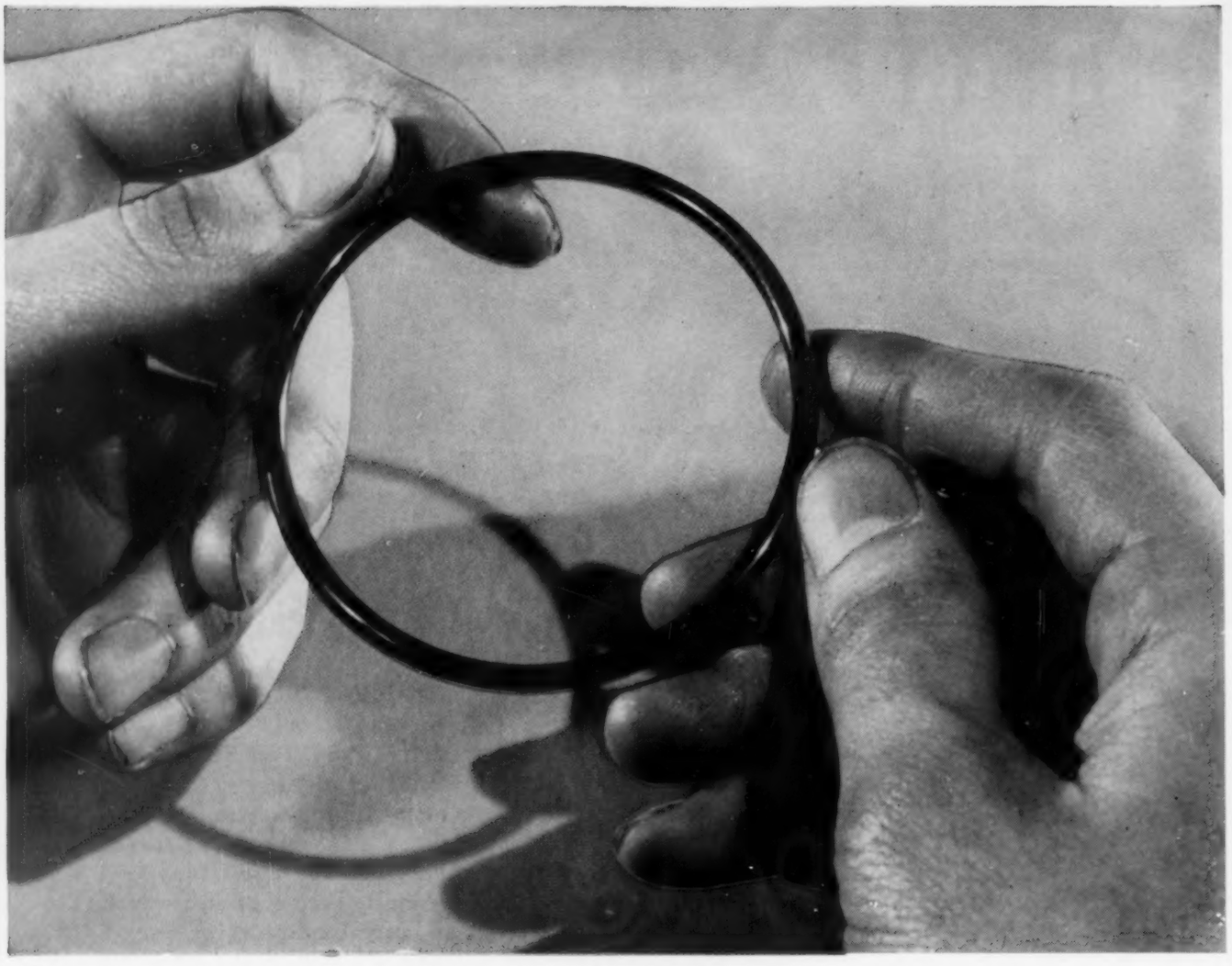


Y F&M

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio



packings with a *plus*

Over the years our engineers have been calling this *plus* the "P-F-M Factor" which boils down to this:

Packings—Fluids—Metals . . .
all three . . . must be *compatible* for maximum hydraulic efficiency!

For example, when each is selected to work best with the others you get longer service from hydraulic equipment, freedom from excessive maintenance, smooth precision operation that lowers costs.

So standardizing on Houghton VIM and VIX-SYN Packings gets you *plus service* no other packings offer:

Packings that are right for the job
because we make all types and sizes

Fluids compatible with their seals . . .
we developed both as a "team"

Metallurgical experience with ferrous and non-ferrous metals used as hydraulic components

Ask the Houghton Man to fill in details on the *plus service* we're talking about. He has a copy of the latest general bulletin, "Packings by Houghton", and data on new standards. See him, or write *E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.*

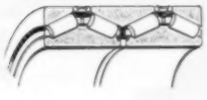
VIM and VIX-SYN PACKINGS
products of . . .

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

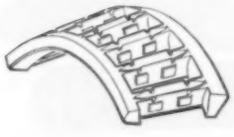
Ready to give you on-the-job service . . .

Here's why **TORRINGTON** work roll bearings establish rolling mill records

Highest quality electric furnace alloy steels are used—carburized and heat treated to provide toughness, hardness, stability and uniformity.



Torrington Work Roll Bearings are designed and built with high thrust capacity to give better service under actual operating conditions.



One-piece cast-bronze cages with machined pads in each roller pocket reduce wear, lengthen bearing life and improve performance.

Accuracy in workmanship is characteristic of all TORRINGTON Bearings. This means a lower cost per ton of your finished product.

Many sizes of TORRINGTON WORK ROLL Bearings are available from stock for immediate shipment.

TORRINGTON WORK ROLL Bearings—both two-row and four-row types—are standard in a wide variety of sizes.

For lower operating costs, greater rolling efficiency, less down time...specify TORRINGTON!

THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

TORRINGTON BEARINGS

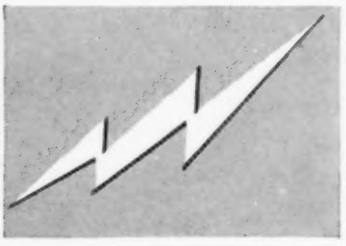
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

NEWS IN TEMPERATURE MEASUREMENT AND CONTROL!

HAGAN MODEL "P" AMPLIFIER SETS NEW RECORDS FOR

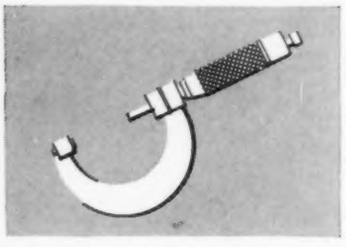
SPEED

FULL SCALE RESPONSE IN 0.1 SECOND



ACCURACY

PLUS OR MINUS ¼% OF INPUT RANGE

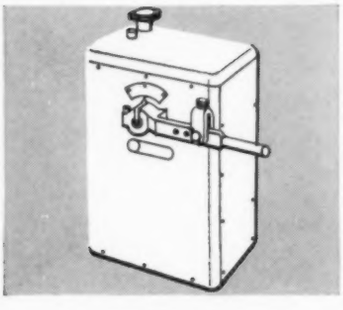


LOW MAINTENANCE

NO SLIDE WIRES — NO REVERSING MOTORS

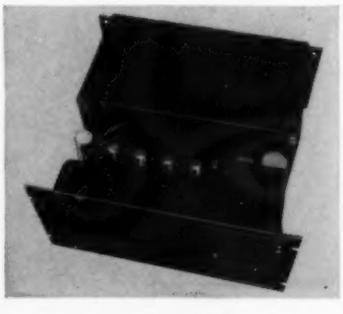
CONTROL

WITH HAGAN ELECTRO-PNEUMATIC CONVERTER



The Hagan PowrAmp Model "P" DC Amplifier boosts over-all steel plant efficiency by making possible more precise temperature control. Use the Model "P" to *record* and *control* temperature of soaking pits—open hearths—heating furnaces—blast furnaces.

Because of its feedback stabilized circuit and its drift-free linearity, the Model "P" provides the steel plant operator with a new and highly efficient method of temperature measurement and control.



HAGAN POWRAMP
MODEL "P" DC AMPLIFIER

Send for Hagan Bulletin MSP-111.1 for the full story on this versatile and money-saving instrument.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

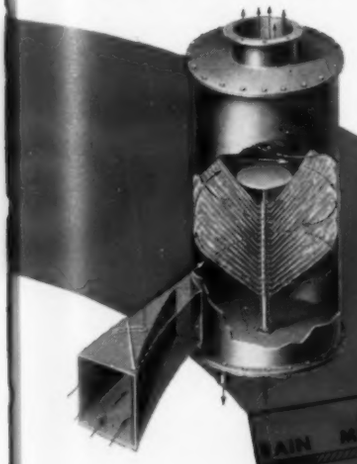
HAGAN BUILDING • PITTSBURGH 30, PENNSYLVANIA

Metallurgical Furnace Control Systems • Control Systems for Aeronautical and Automotive Testing Facilities • Boiler Combustion Control Systems • Ring Balance Flow and Pressure Instruments

The first 2 steps to eliminate

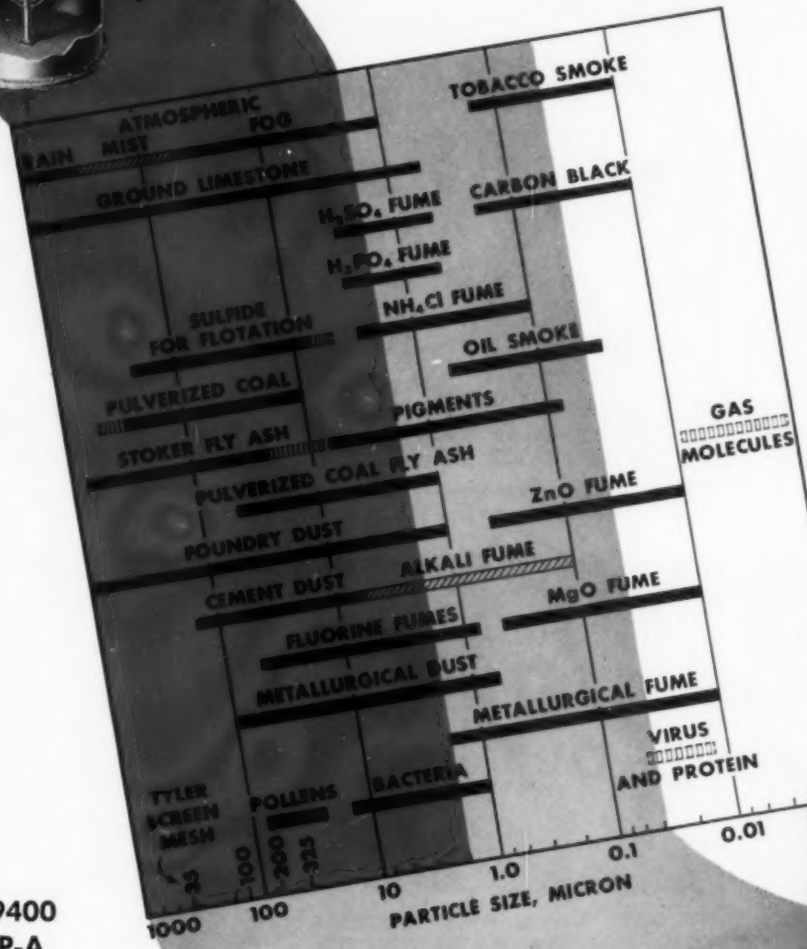
DUST or FUMES

in your plant



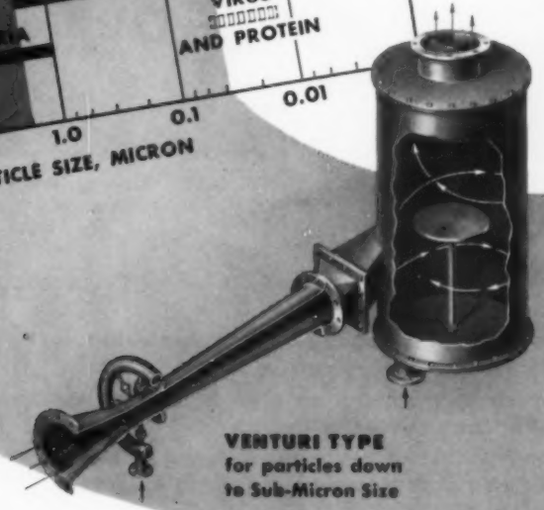
CYCLONIC TYPE
for Micron Size
particles

1 Pick out your dust or fumes in this chart of particle sizes to determine the type of P-A Scrubber to be used



2

Phone LO 4-9400 or write our P-A Sales Dept. for further information, and ask for our Bulletin M102 on Pease-Anthony Gas Scrubber



VENTURI TYPE
for particles down
to Sub-Micron Size

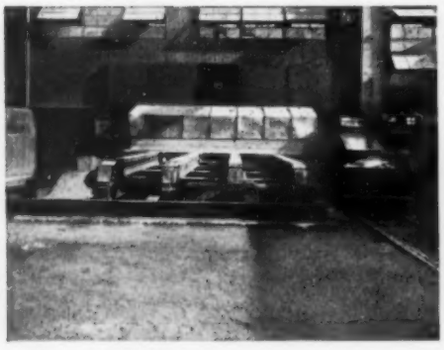
CHEMICAL CONSTRUCTION CORPORATION
A Unit of American Cyanamid Company
525 WEST 43rd STREET, NEW YORK 36, N. Y.
Technical Representatives Throughout the World
Cable Address: CHEMICONST, N. Y.

CHEMICO P-A SCRUBBER

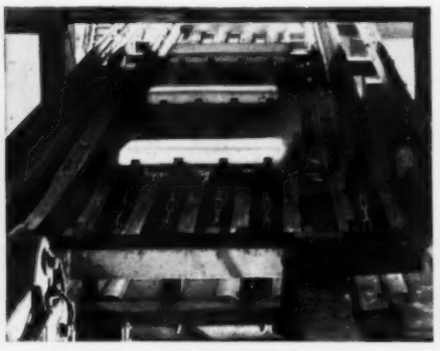
CC278

CHEMICO
CHEMICAL CONSTRUCTION CORPORATION

How LINK-BELT helps cut costs of handling steel in every form



SLABS—Up to 70 tons of hot slabs are easily carried by 4-strand chain conveyor.



BILLETS—Dependable Link-Belt chain with pusher attachments transfers steel billets.

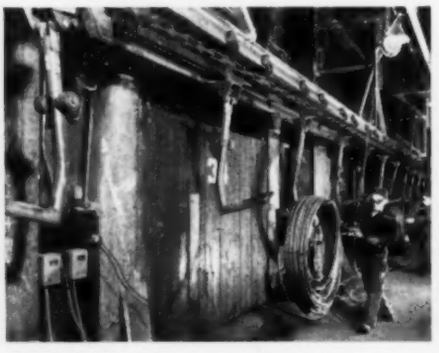
PLATES are transferred from hot run to cold run tables on 51 strands of steel chain.

TUBES—12 endless strands of Class H pintle chain serve this modern pipe cooling rack.

SKELP—Hot skelp moves to the reels on a Link-Belt steel apron conveyor 108 in. wide.

SCRAP—At this mill, scrap is handled on a completely mechanized Link-Belt system.

COILS—Up to 75,000-lb. coils are carried on Link-Belt conveyors—gently, safely.



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MILL SCALE recovery was boosted from 250 to 475 tons a week by Straightline Collectors.

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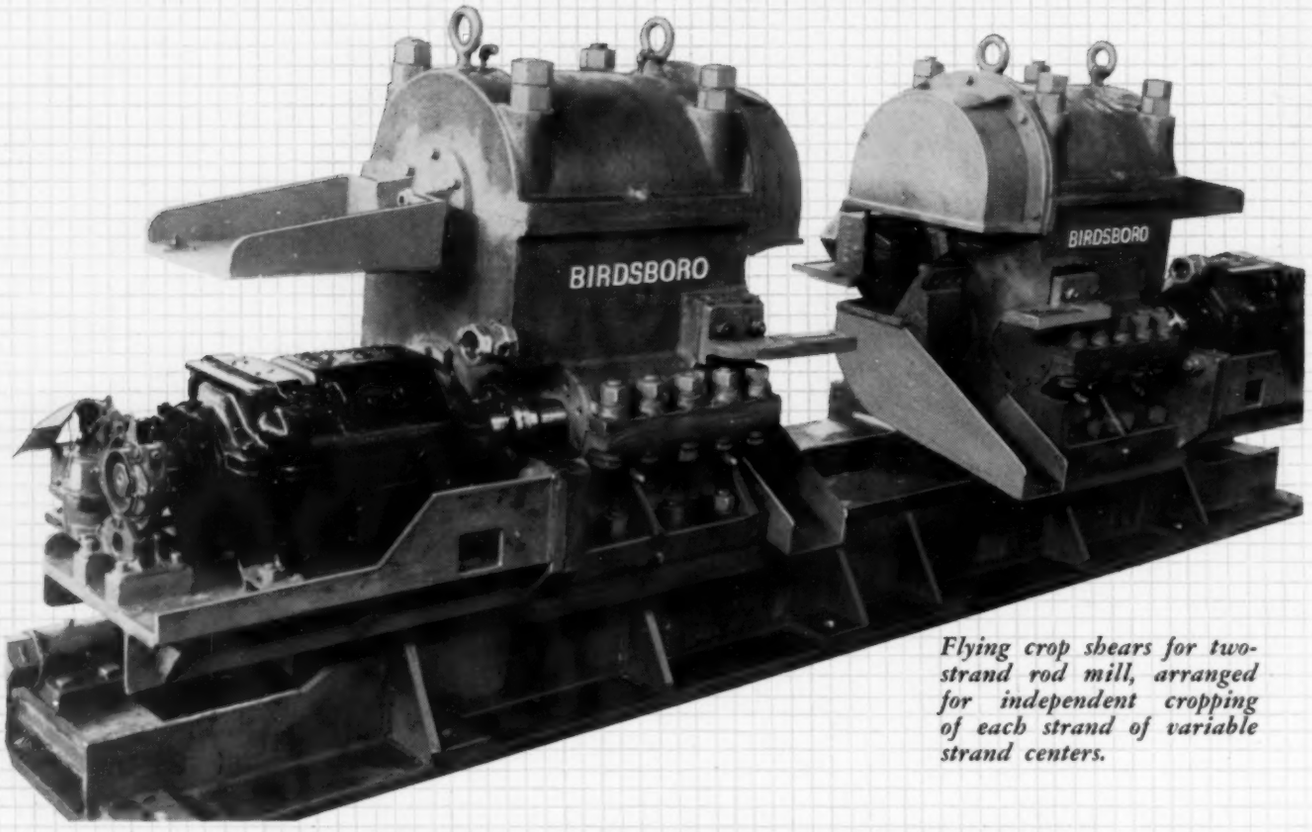

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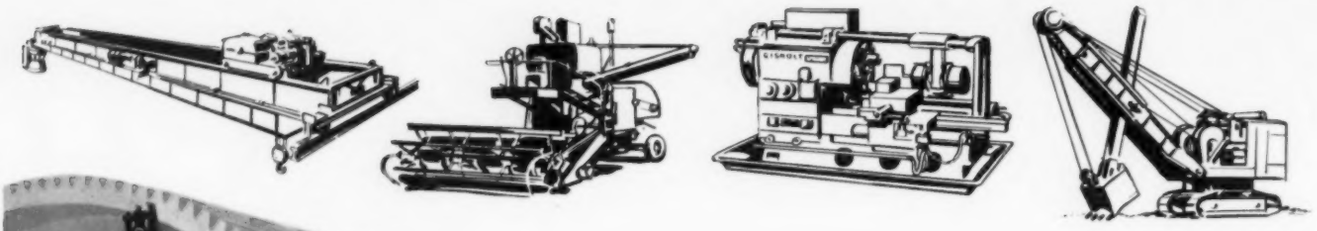

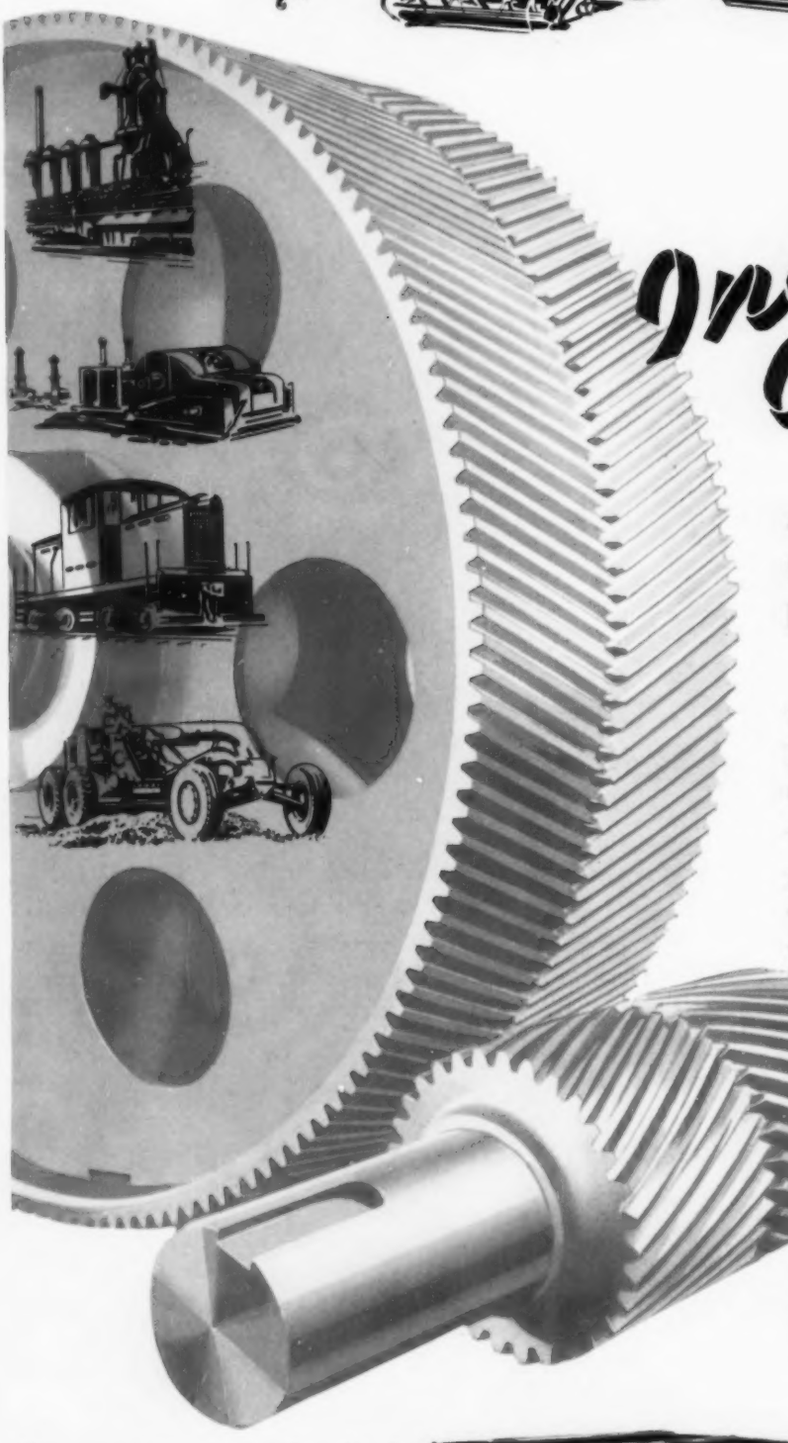

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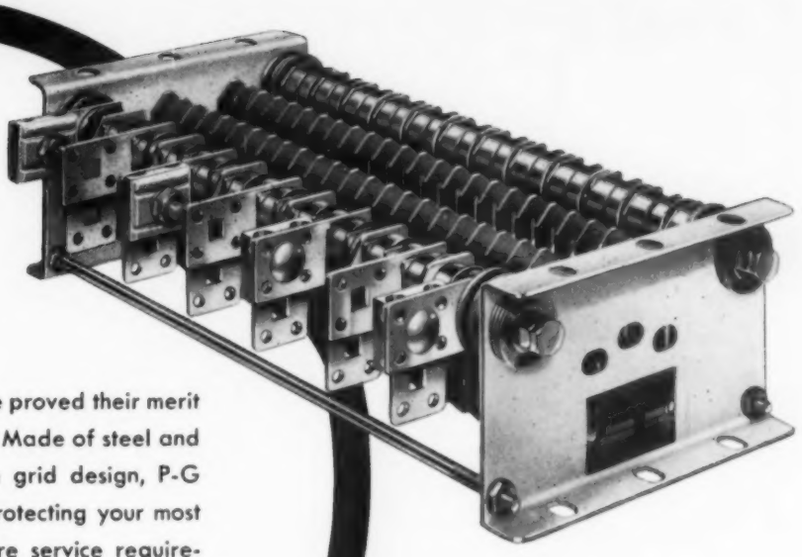

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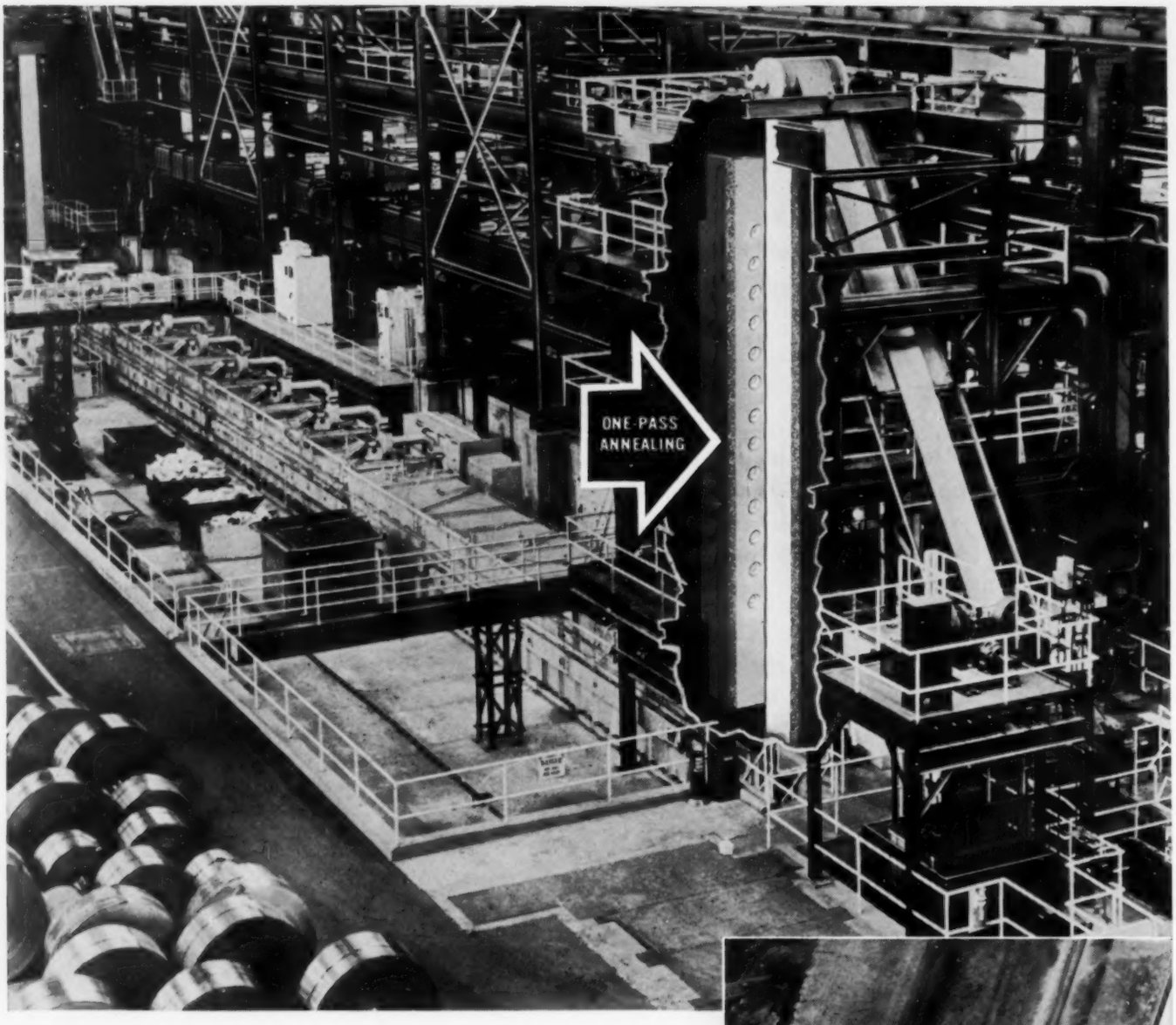

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THIS continuous bright annealing-galvanizing line uses SELAS GRADIATION strip annealing to obtain tight adherence of coating and high quality of product. Two new galvanizing lines scheduled for this year will also rely on Selas radiant-gas-burner heating . . . precisely applied . . . unsurpassed for uniformity across strip width.

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Write for descriptive literature on strip annealing.

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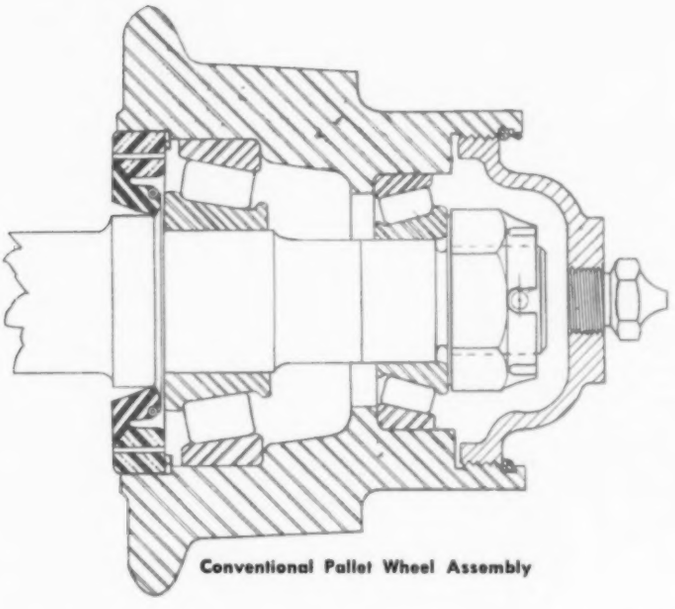

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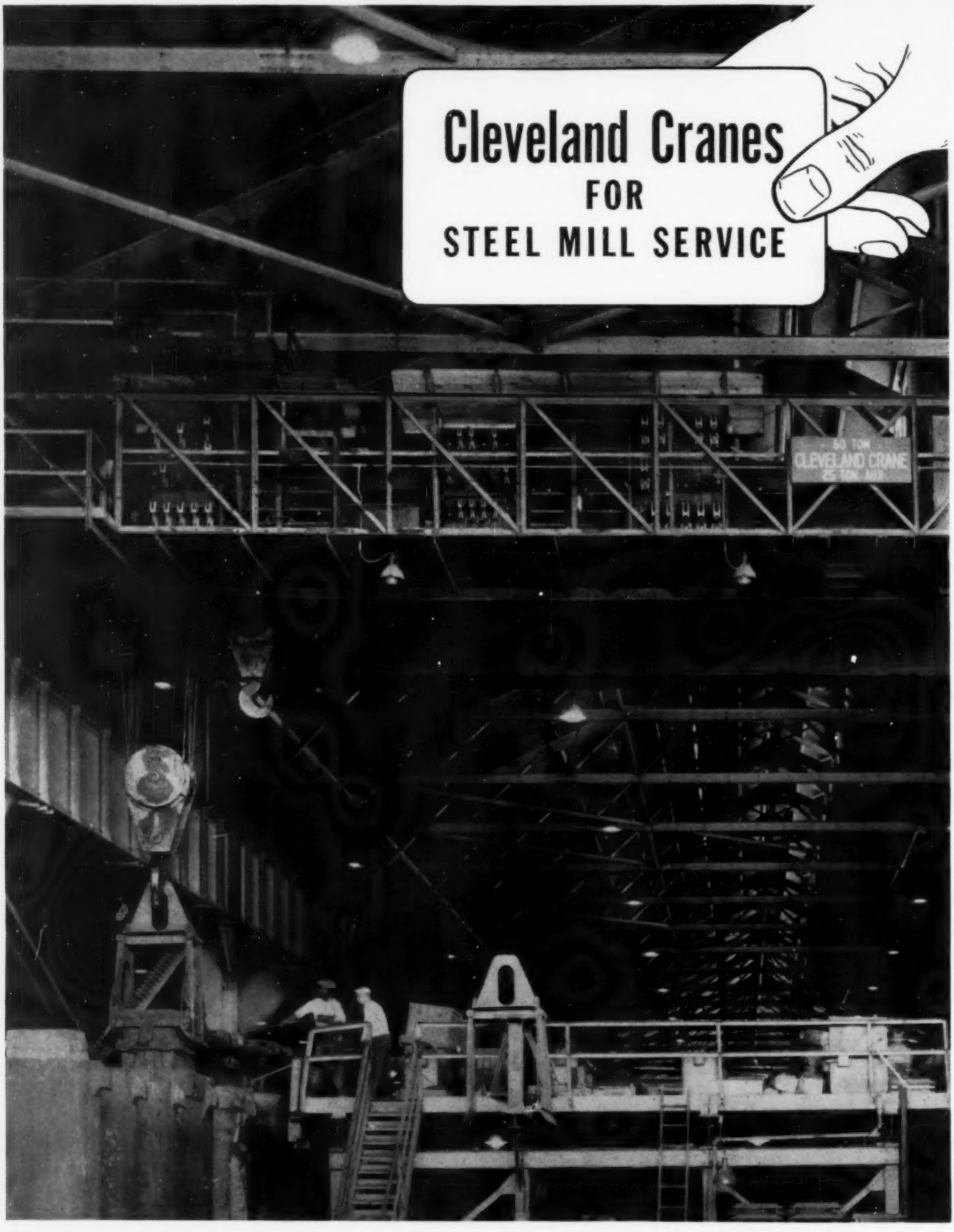

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

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Crops and Shorts

THE AISE 1955 Spring Conference at Detroit ended up with a total registration of 696 men. Papers presented at the technical sessions were well received, with particularly high interest in the off-the-record forum on rolling mill problems. Great Lakes Steel Corp. staged a fine inspection trip for the group, and Hotel Statler cooperated in excellent fashion to make the meeting completely successful. A pictorial roundup of the meeting is published on pages 104 and 105 of this issue.

▲

GENERAL business continues to improve. Steel production continues to rise and is currently running above 96 per cent capacity. Automobile production and sales are at record levels. Construction activity rose to a new peak of $2,900,000,000 in March. Department store sales are 9 per cent ahead of last year. Gross national product is at an annual rate of $370,000,000,000. Personal income has hit a new record rate of $292,500,000,000. The stock market averages have reached 25-year record highs. A survey made by the Securities and Exchange Commission and the Department of Commerce indicates capital spending of more than $27,000,000,000 for plant and equipment . . . . Yet a few companies are trimming their sails in a manner strongly reminiscent of depression times. We hope they won't find themselves in the same predicament as the economist mentioned recently in Newsweek, which quoted a corporation executive as saying: "Only one of our staff economists thought this year would be worse than last year. He's no longer with us."

▲

LAST month this column mentioned a new production record at Inland Steel Co. for March. In April, a 30-day month, Inland again set a new record, producing 439,160 tons of steel ingots for an average of 106.8 per cent capacity.

▲

AN old timer tells us that the bigger a man's head gets, the easier it becomes for someone else to fill his shoes.

▲

ACCORDING to figures released by the American Iron and Steel Institute, steel shipments in 1954 included 52 per cent of flat rolled material (plate, sheet, tinplate and strip). Light gage products, consisting of sheet, strip, tinplate, bars and wire, made up 66.4 per cent of the total, the highest annual percentage they have ever attained. This trend should help the industry's financial picture, as such items are generally more profitable than heavy products. Shipments in 1954 totaled 63,152,726 net tons.

▲

FOR every 1000 inhabitants, the United States has 330 automobiles, 290 telephones and 910 radios.

▲

A moderate decrease in automobile accidents was reported in 1954, but! . . . . nearly 2,000,000 casualties were recorded for motor vehicle accidents . . . . 35,500 Americans were killed in traffic accidents . . . . still lots of room for improvement.

▲

SAFETY records in the iron and steel industry improved in 1954, with the frequency rate dropping 19 per cent to a new low of 3.85 disabling injuries per million manhours and the severity decreasing almost 20 per cent to .87 days per thousand manhours.

▲

THE revenue department sends out tax blanks but they certainly set off some terrific explosions.

▲

PRODUCTION of iron ore in the United States for 1954 totaled 87,200,000 net tons, of which 78 per cent came from the lake region, 7.5 per cent from western states, 7.2 per cent from southern states, and 4.5 per cent from New York.

▲

THE American Iron and Steel Institute reports the 1954 average hourly payroll cost of wage earners in the industry at $2.333. Pensions, insurance and social security costs bring the total employment cost up to $2.51 per hour.

The industry's total payroll for 1954 is estimated at $2,908,339,000, the second highest in history. Total employment averaged 611,000. Wage earners worked an average of 36.1 hours a week.

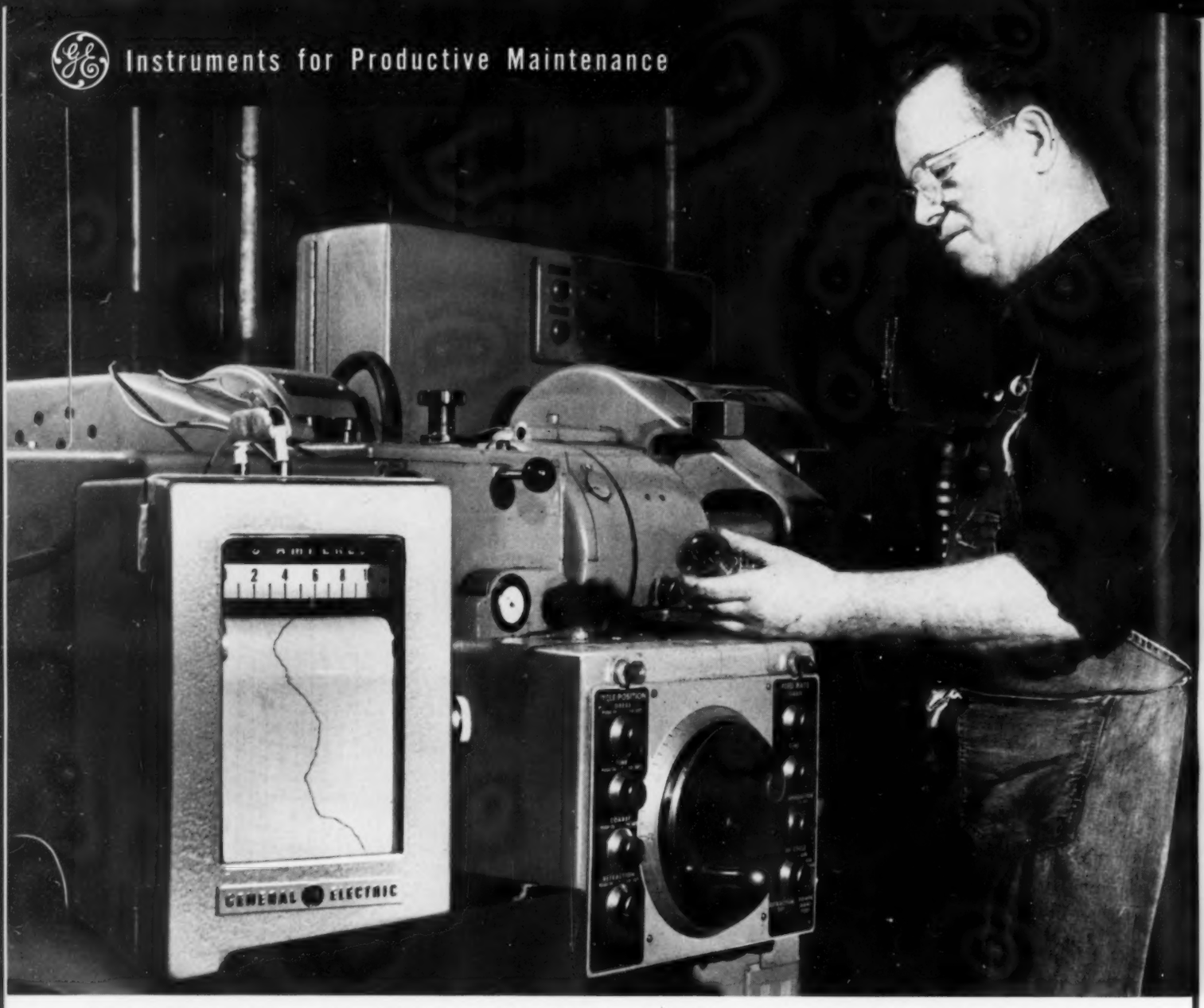
▲

A survey of 104 public school systems in 44 states shows only one out of four high school students studying languages, less than half taking mathematics, one out of 20 taking physics. Instead of these traditional preparatory courses, group action subjects, which can often be "bulled" through without cracking a book, have become popular.

Professor J. F. Latimer, of George Washington University, has been quoted in Time magazine as saying: "We have gotten away from individual effort . . . . By permitting the high schools to become the vocational bargain basements of education, we have insulted the student's intelligence and encouraged mediocrity by prescribing mediocre subject matter as an incentive for mediocre minds."

An article in the M.I.T. Technology Review suggests that secondary schools should take over more of the liberal arts training now given in colleges, and really prepare students for college. It also suggests contrary to some of the present day thinking, that, in technical schools, the humanities should be optional subjects.

Instruments for Productive Maintenance



NEW G-E RECORDER, designated Type CH, has two modern styles in switchboard cases, in addition to the portable shown in operation above. Checking the efficiency of a lathe is just one of many applications of this new, versatile general purpose instrument.

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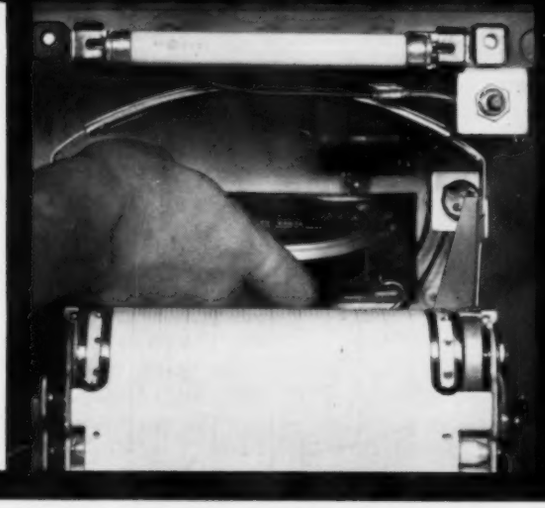
New G-E Recorder Makes Clear Records Accurate and Easy to Read



NEW PLASTIC INKWELL holds full 3 ounces or triple amount of open kind. Comes sealed ready for insertion. You waste no time—spill no ink. After use—throw it away.

STURDY CONSTRUCTION of inking system combines fine writing qualities with extra long life. A highly polished, special alloy pen point reduces wear to a minimum.

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G-E RECORD ROLLS are 150 feet long and service is simple and easy. Handy side paper indicator tells quickly how much is left on paper roll, saves time, steps.

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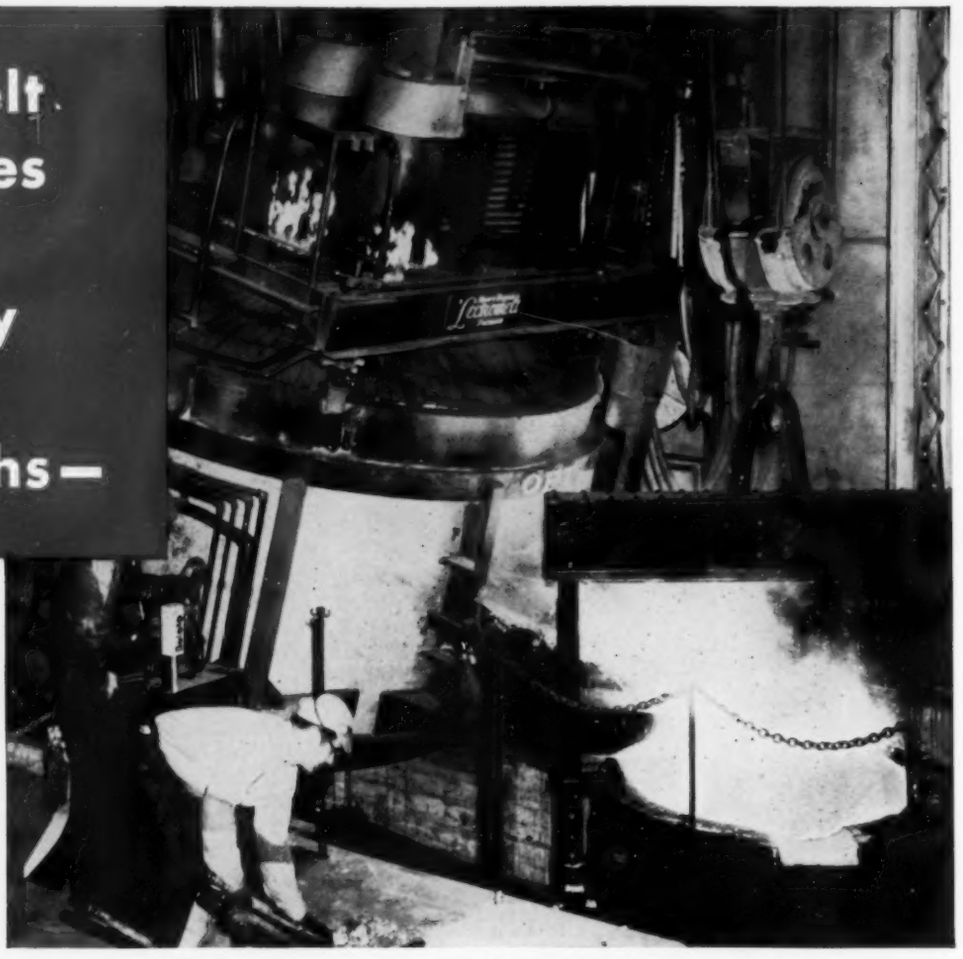

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By ROBERT R. SHEDD

Design Engineer, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

. . . . layout of cold reduction mills was set up to further a predetermined efficient product flow plan . . . . operation has been very efficient . . . . additional economies have also resulted from consolidation of facilities and personnel to service both mills . . . . mills are of unusually rugged design and planned for high rate production . . . .

▲ FACILITIES installed by U. S. Steel Corp. at the new Fairless Works consist of a 21 and 53 × 48 in. five-stand tandem mill, and a 21 and 56 × 80 in. four-stand tandem mill. The five-stand mill, designed to produce tin plate gages in widths from 18 to 39 in., is powered with 21,650 connected hp, and has a maximum delivery speed of about 7000 fpm. The four-stand mill, equipped also with 21,650 hp, is designed for the production of cold rolled sheets in gages ranging from 0.024 to 0.075 in. and in widths of 18 to 72 in., at maximum delivery speeds of about 3100 fpm.

Fairless Works has the distinction of producing one of the largest hot rolled coils in the industry, with a weight averaging 520 lb per in. of strip width up to 50 in. wide, and totaling around 25,000 lb for widths from 50 to 72 in. Thus, coiled product delivered to the cold reduction mills weigh about 500 lb per in. of width for single coils, and 1000 lb for double or welded coils with maximum coil weights of 36,000 lb for tin plate and 50,000 lb for cold rolled sheets. Processing of double coils with a single weld is conducive to improved cold mill performance and production.

Location of these cold reduction facilities with respect to preceding and succeeding operations comprises a generally satisfactory product flow development. Coils delivered to the pickled coil storage area adjacent to the bay housing the two mills are conveyed by means of two apron type driven conveyors, one interconnecting the raw coil pickler with the storage area, and the other serving as temporary storage prior to stocking. All product is stocked with the coil axis horizontal. An overhead crane equipped with motorized tong is provided for the stocking operation as well as charging entry conveyors on the two mills. Cold reduced product is discharged into the adjacent bay at the delivery ends of the two mills, designated as coil scheduling and stocking area, preparatory for annealing on the continuous annealing line or in batch annealing with electrolytic cleaning facilities available for optional treatment. Essentially all coiled product for continuously annealed tin plate is handled directly off the mill by ram tractor. Overhead cranes are provided for transfer of coiled product scheduled for batch annealing.

The decision to install the two cold reduction mills across the building was predicated primarily on the development of the above described product flow scheme. In the design of buildings, equipment foundations, proximity to services of varied types and finally utilization by the operating department, other advantages became apparent. For example, the oil and hydraulic cellar, located under the entry of the two mills, services both facilities with a minimum of attending personnel.

Design of the foundations for these facilities is of interest to the extent that a "tub" type of foundation was utilized. Due to the urgency of construction at the

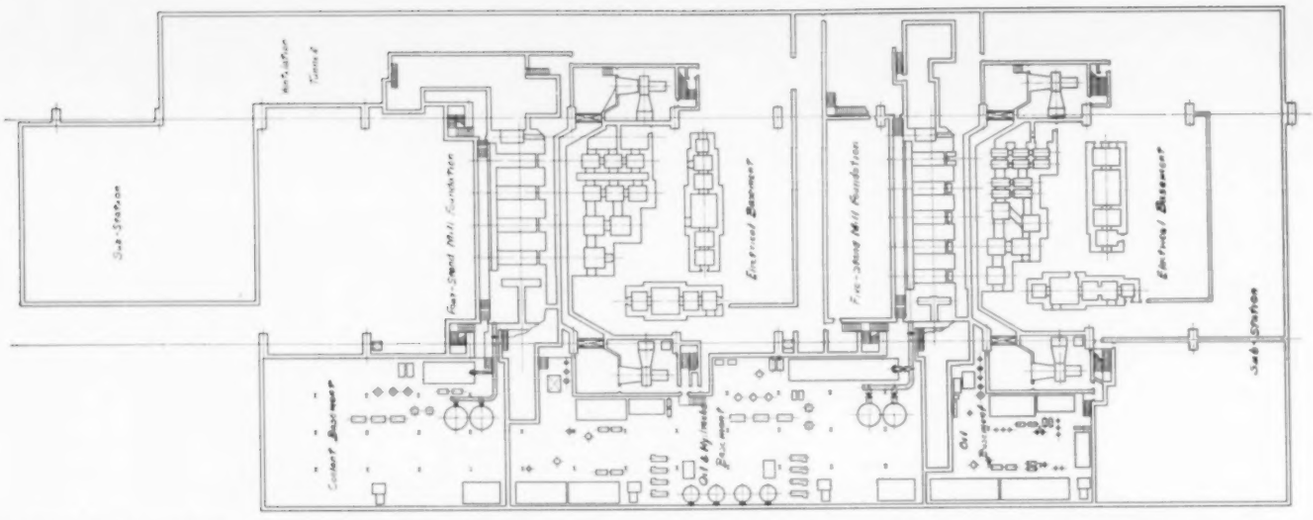


Figure 1 — Foundations were poured long before many design details were established. Outline shows concrete pads and perimeter walls for mill foundations.

early stages, it was decided to begin with a reinforced concrete pad and perimeter wall type of construction, within which building piers were poured integral with the pad and interior walls in order to secure favorable working conditions as the design and development of machinery progressed. Figure 1 shows foundation outlines on this installation. Over 35,000 cu yd of concrete and about 3,500,000 lb of embedded steel were required for these foundations inclusive of integrated substations, deck slab, building piers, and equipment foundations. No piling was employed for these foundations as soil bearing characteristics were satisfactory in this particular location. The entire foundation mat and walls up to an elevation of about ten feet below floor level were water-proofed with bituminous coating and fabric due to the relatively high water table in existence.

Substations were included in the foundations and buildings and contain in addition to the electrical power facilities for the two mills, complete air filtration systems for each mill. Volume of air required for drive motors and main and auxiliary motor-generator sets totaled 383,000 cfm for the five-stand mill, and 353,000 cfm for the four-stand mill. Filters are electrostatic precipitrons equipped with semi-automatic washers. Ventilation air is 100 per cent fresh make-up.

Electrical power distribution system constitutes a double circuit of 69,000 volts for the plant, which connects the public utility source at one end with the plant's power house at the other end. The main outdoor substation for the sheet and tin division supplies 13,800-volt circuits to various indoor or facility substations. The two indoor substations serving the cold

TABLE I

Mill Stand Drive Equipment 48-In. Five Stand

Type of motor	Mill stands					Tension reel
	1	2	3	4	5	
	Single armature	Double armature	Single armature twin	Double armature twin	Triple armature twin	Double armature
Horsepower (total)	1750	3500	4500	4500	6000	1400
Motor rpm	110/310	165/420	200/415	300/625	345/635	350/1700
Pinion stand	Yes	Yes	....	....	....	....
Geared speed increaser	....	....	1.51:1	1.51:1	2.01:1	....
Maximum speed in fpm	1710	2320	3460	5210	6985	7340

TABLE II

Mill Stand Drive Equipment — 80-In. Four-Stand

Type of motor	Mill stands				Tension reel
	1 Single armature	2 Double armature	3 Triple armature	4 Triple armature	Double armature
Horsepower	3000	6000	6000	5250	1400
Motor rpm	90/270	150/350	200/500	250/565	150/525
Pinion stand	Yes	Yes	Yes	Yes	....
Maximum speed	1485	1925	2750	3110	3300

reduction mills supplies 13,800 volts for the main motor-generator set synchronous motors (14,000 and 10,500 hp for the five-stand and 15,000 and 10,500 for the four-stand), 2400 volts and 480 volts, 60-cycle for variable voltage auxiliary equipment, and 250 volts d-c for constant potential auxiliaries. In addition to the two tandem mills, these indoor substations serve other facilities in the near vicinity.

Tables I and II identify mill drive equipment for the five-stand and four-stand mills respectively. Electrical drive horsepower ratings were established on the basis of cold reducing pickled strip of 0.076 in. in thickness by 30 in. in width to a final gage of 0.0093 in. on the five-stand mill at a rolling speed (delivery) of 7000 fpm. Under these rolling loads with weak field setting on each motor, acceleration can be made to full rated speed in 10 sec. Drives on the four-stand mill were designed to cold reduce pickled strip of 50 in. in width by 0.100 in.

Figure 2 — Layout of 48-in., 5-stand cold reduction mill.

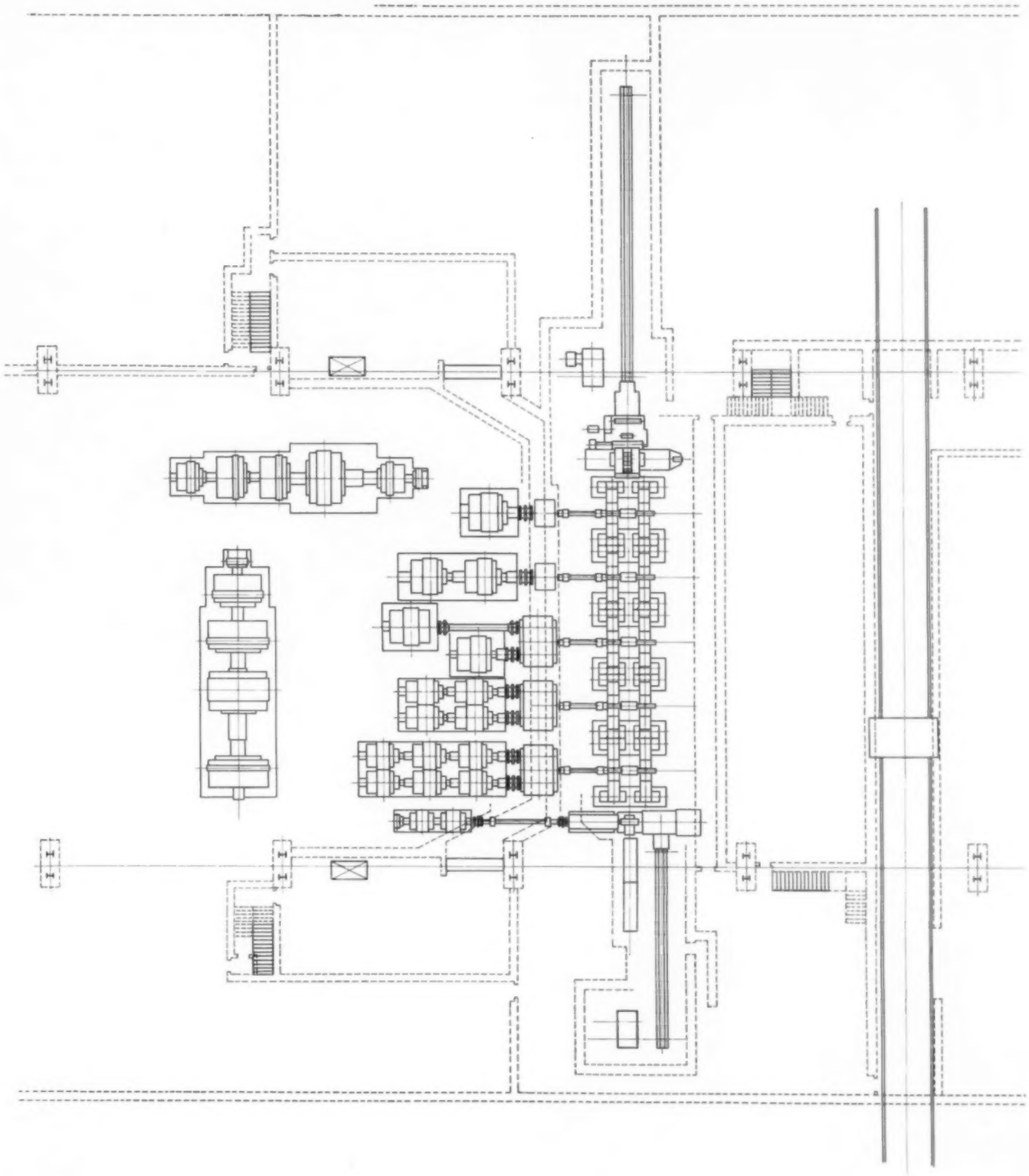


Figure 3 — Mill stands of 5-stand mill are on 13-ft 8-in. centers.

in gage to a finished thickness of 0.035 in. at maximum delivery speed.

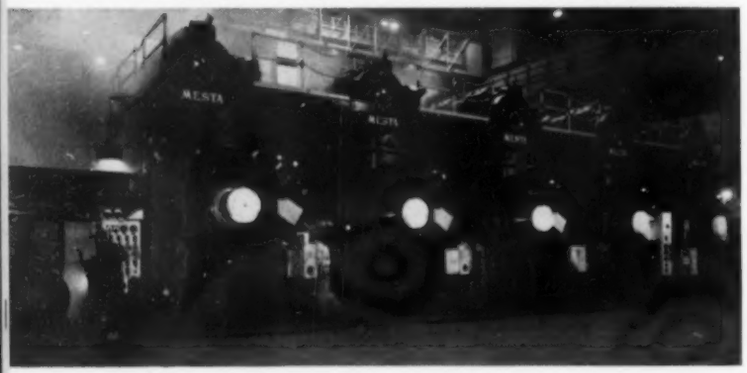
Electrical control scheme is based on a single generator per mill stand drive. To reduce WR^2 at top speeds and also to enhance acceleration and deceleration characteristics, use is made of double and triple-armature motors with fields cross connected to obtain load balance.

Mechanical equipment furnished for the five-stand mill, shown in plan by Figure 2 and in Figures 3, 4 and 5, is comprised of five four-high mill stands close coupled on 13 ft 8 in. centers. The mill stands are essentially conventional in appearance, but have 1000 sq in. of post sectional area and are exceptionally rigid. The hold down or entry guide box of each mill stand is pneumatically operated and opens to 10 in. clearance to facilitate threading. Boards and brass liners are inserted from the entry side and clamped in place. Stripper guides installed on the delivery side of the mill stand are pivoted from brackets attached to the back-up roll chocks. Cobble guards were also provided and are mounted above the pass line on the delivery side of the mill stand to prevent entrance of the strip in the work roll—back-up roll bite. Tensiometer roll, used for determination of strip tension between stands, is located between housing posts of the delivery side of mill stands 1 through 4 inclusive.

Work rolls when new are 21 in. in diam and may be used to a worn dimension of 18¼ in. Double radial row roller bearings with high thrust and radial loading characteristics were designed specifically for this application. Back-up roll bearings are of the oil film flood lubricated type, and are protected with continuous temperature measuring recording instruments.

Entry equipment for these mills is shown on Figure 6, and consists of coil conveyor, coil stop and lowering device, coil positioner, coil box, and entry pinch rolls. The 60-ft entry conveyor installed at floor level is an apron type pallet 30 in. wide, mounted on springs to absorb shock when loading by overhead crane, and is driven with a 25-hp motor and gear reducer unit, developing a speed of about 18 fpm. An hour's rolling can be stocked on the conveyor. Coils delivered off the conveyor are rolled onto a hydraulically operated coil stop and lowering device, so designated due to the required change in elevation from conveyor level to the succeeding coil positioner. The latter equipment is comprised of two driven rolls pivoted for three-position operation. When receiving the coil, the positioner is in the maximum raised position to properly retain the coil as it is rolled off the aforementioned lowering device.

Figure 4 — Mill housings are unusually rigid.



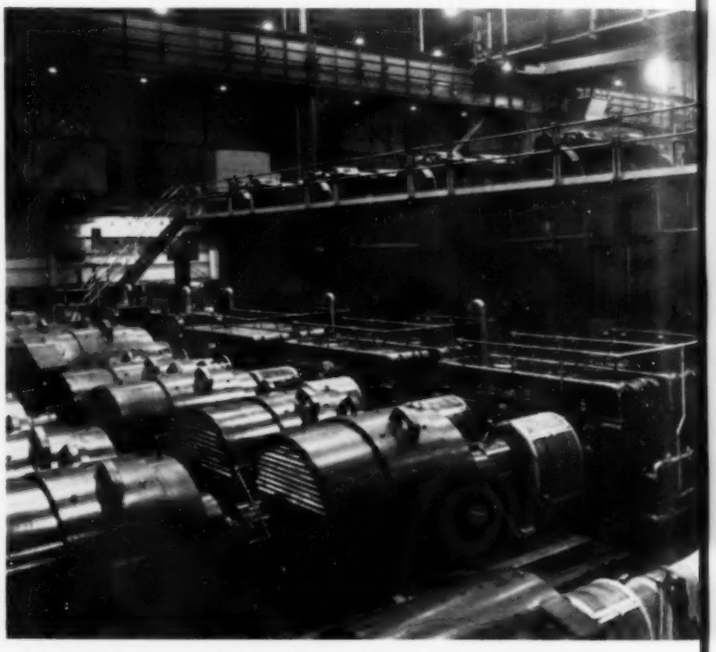


Figure 5 — View shows drive side of 5-stand cold mill.

The coil positioner is then lowered to the second position, and the coil is rotated in either direction to permit removal of strapping and straightening of the coil end. The lead end is placed between the pinch rolls, top roll of which is driven, and sufficient strip is payed off preparatory for threading the first mill stand. After the strip is entered into the mill, the coil positioner is lowered further, thus permitting the coil to enter the coil box. Operation of the coil box provides for optional use of snub-nosed mandrels or idler rolls mounted on a hydraulic hoist, and is confined by rotating side guides. This arrangement permits complete preparation of the succeeding coil during the rolling of the coil in the coil box.

Delivery equipment on the five-stand mill includes both contact and non-contact gages, tension reel, belt wrapper, stripper buggy, scale and conveyor. The non-contact gage is of the X-ray type and is required to obtain accurate gage determination at high rolling speeds. Instrument is mounted on a traverse mechanism

that permits rapid retraction from or insertion into the strip pass line. The tension reel has a 16½-in. diam block and is direct driven. Housing contains two hydraulic cylinders, one for the stripper plate and the other for the stripper buggy. The latter is designed for a 6 ft-4 in. traverse running free of interferences on a heavy fabricated steel framework, which, in turn, is carried on four load cells connected to an electronic scale. Weights are determined as soon as the coil is stripped off the reel, and prior to depositing on the delivery conveyor. Coils are conveyed into the adjoining bay with the 40-ft delivery conveyor, similar to the above mentioned entry conveyor except for the spring mounting feature.

Screwdown motors are 75 hp, 515 rpm, d-c motors with variable voltage control. For roll changes, motor speed is increased to about 1200 rpm, equivalent to a screw movement of 1½ in. per min. During normal rolling operation, screw adjustments are made at reduced motor speeds.

Mill spindles were designed to provide a maximum misalinement of about four degrees. Clearances of the universal joints and between half coupling and drive shaft and roll neck are held close to prevent tendency for the couplings to run eccentric. Initially, spring loaded spindle carriers were installed, but at elevated mill speeds, a harmonic vibration was developed on the last three finishing stands. Installation of counterweighted balanced type spindle carriers eliminated vibration at all mill speeds.

Mill stands 1 and 2 are driven through pinion stands and twin gear speed increasers are employed for drives on mill stands 3, 4 and 5. The latter has a gear ratio of 2:1 and 3 and 4 mill stand twin gear drives are 1.51:1. The twin gear drives permit operation of the mill with mismatched work rolls, as the pinions in the drive are not joined mechanically. Work roll peripheral speed is matched electrically through load control.

Back-up rolls are changed with C-hooks on both mills, and work rolls of both mills are changed with roll changing sleeves.

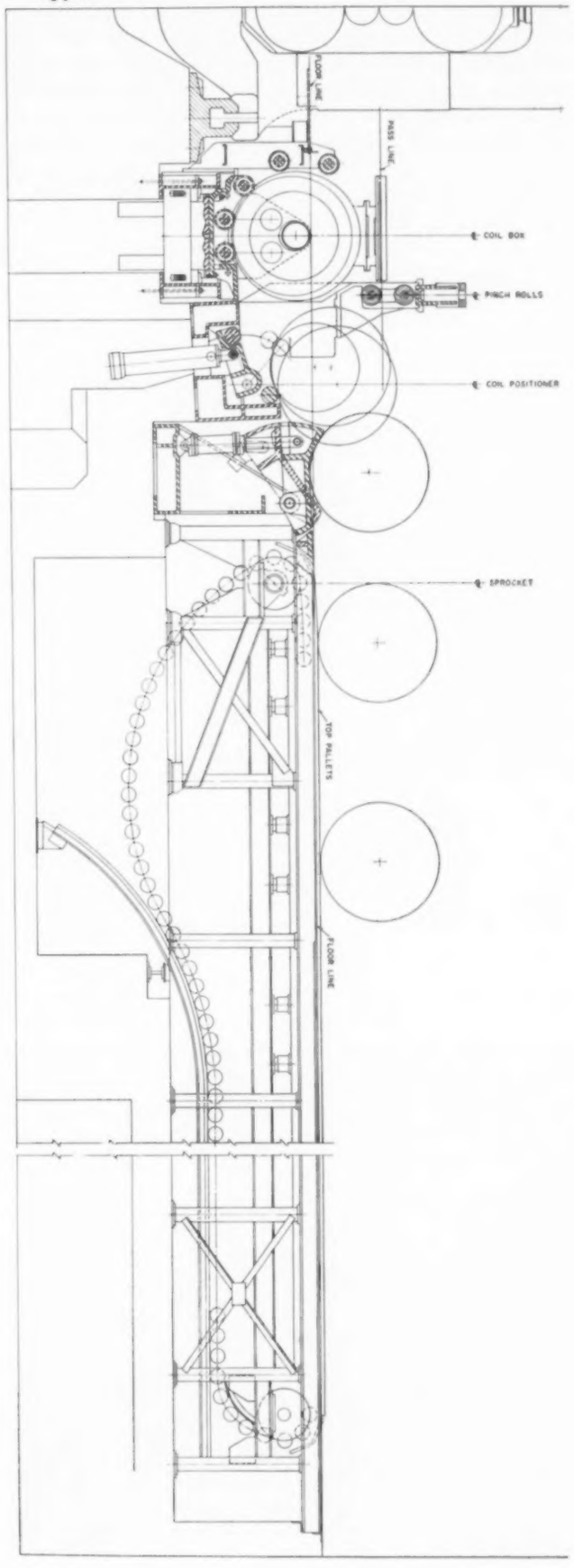
Strip and roll coolant systems provided for this mill comprehended the experience developed to the present time on other high speed mills in the industry. However, in view of the delivery speed potential, it was decided to install a dual system basically comprising flood lubrication and cooling using an oil-in-water type coolant, and direct application of oil and/or water-in-oil type lubricant with water as the coolant. The oil-in-water coolant system consists essentially of a recirculating type of system in which the total volume, constituents and temperature are constantly being controlled. Spray headers are installed both above and below pass line on both entry and delivery sides of the

TABLE III

48-In. Five-Stand Mill Lubrication Systems

System	Application	Storage capacity	SSU
No. 1	Motors and motor-generator sets	4,000	295
No. 2	Pinions and screwdowns	6,000	1760
No. 3	Twin gear drive units	9,000	1330
No. 4	Back-up bearings — No. 1 and No. 2 mill stands	8,000	1800
No. 5	Back-up bearings — No. 3, No. 4 and No. 5 mill stands	24,000	1100

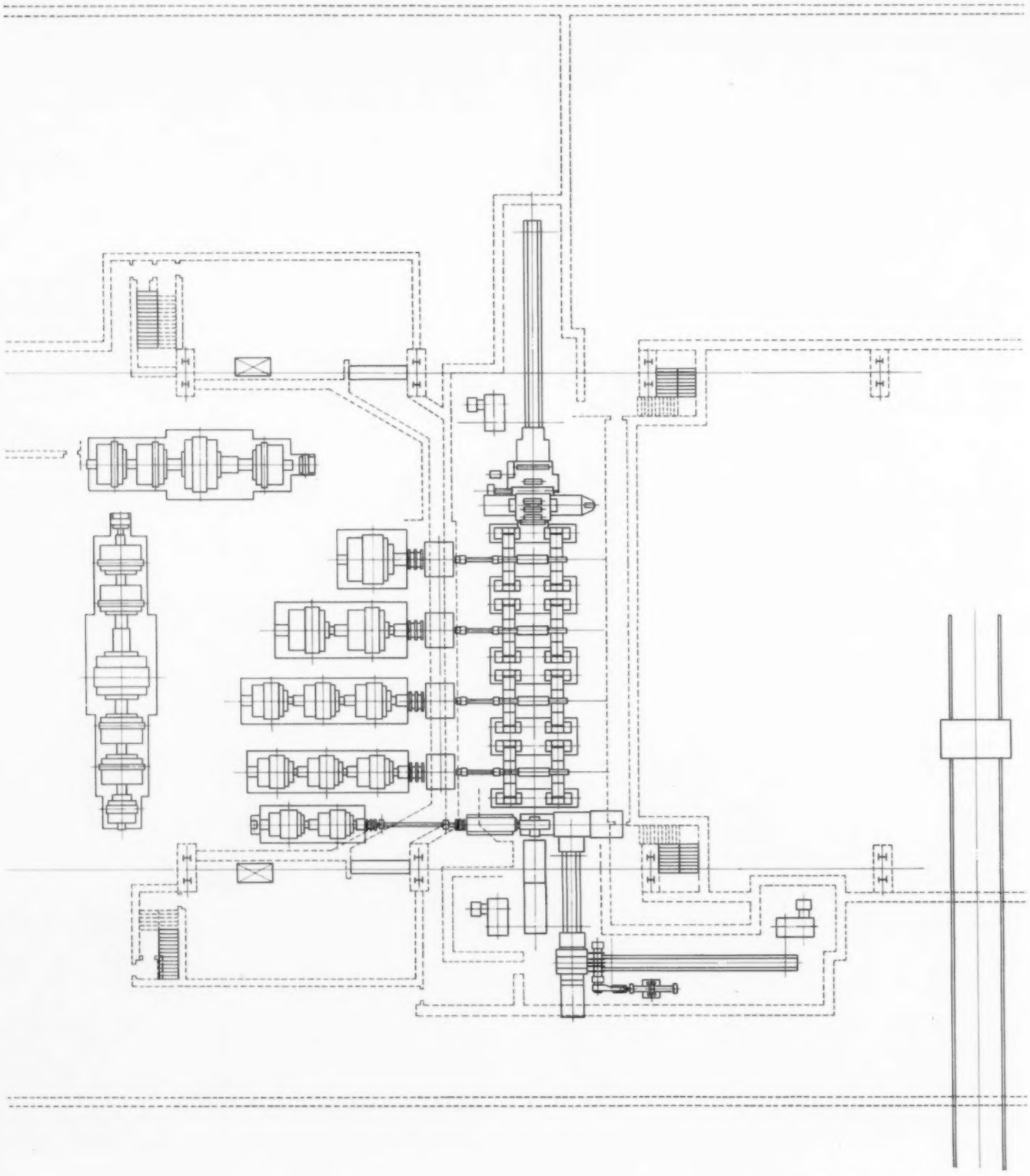
Figure 6 — Entry conveyor is 30 in. wide and of the apron type.



mill stands. Solution is pumped to the mill from one of two 8300-gal storage tanks by three 2000 gpm pumps driven by 200-hp motors on each pump. Operation of the pumps so far has been contingent somewhat on operating requirements, the most successful practice utilizing one of the three pumps as a booster. Mill stands 1, 2 and 3 are supplied with about 2000 gpm total at 120 psi, and mill stands 4 and 5 with 2000 gpm at 190 psi, thus providing the maximum amount of cooling where heat development is extremely critical to production of flat strip. To assure cleanliness of coolant and avoid clogging of spray nozzles, strainers are installed ahead of the pumps, and filters on the pressure side of the pumps. Solenoid pilot operated valves divert coolant from the mill stands during threading operation.

The direct application system has not been used extensively thus far, but is occasionally used in conjunction with the above described coolant system. Cold water boosted in pressure by use of the rolling coolant pumps will be applied on the delivery side of the mill stands, and palm oil sprayed on the strip at the entry

Figure 7 — Layout of 80-in., 4-stand cold reduction mill.



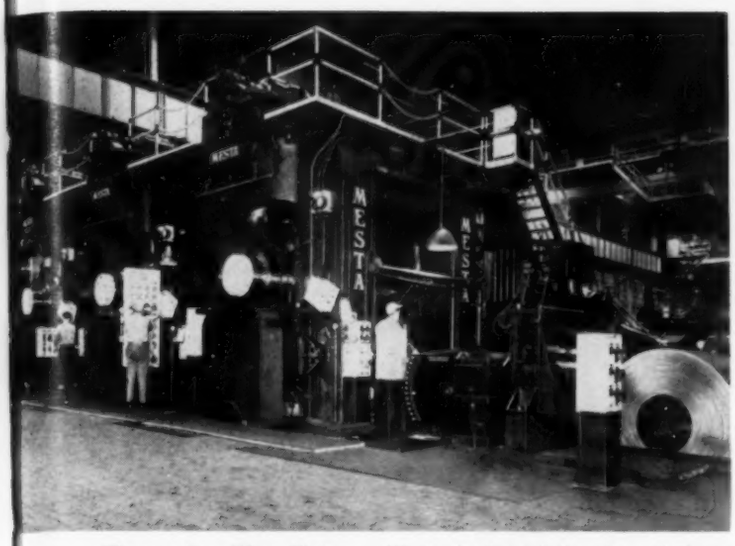


Figure 8 — The 80-in. mill is designed for top delivery speed of 3100 fpm.

side of the mill stands. Of interest here is the operation of a large 20,000-gal retention or skimmer tank for collection of sludge and spent palm oil. All coolant applied on the mill stands is returned in a flume cast integral in the mill foundations. When rolling with the direct application system, such wastes are collected in the skimmer tank. A part of the water is discharged to the oil interception plant along with the spent palm oil recovered by flotation, the balance of the water being reused on the mill. Water consumption under this plan is not expected to exceed 1000 gpm during mill operation.

The five-stand mill is equipped with a total of five lubrication systems plus a centralized grease lubrication system. Lubrication systems are designed to deliver oil in specified quantities at very closely controlled temperatures. Oil is retained in large storage tanks providing holding capacity of at least forty times the volume in service and is further filtered to assure utmost cleanliness.

Table III identifies lubrication systems on this mill.

The 80-in. four-stand mill, shown in plan by Figure 7, and in Figures 8 and 9, consists of four four-high mill stands set on 15 ft 0 in. centers, having a post sectional area of 1100 sq in. Many of the features of this mill are essentially identical to those of the above described five-stand mill with respect to entry guide boxes, stripper guides, spindles, tensiometer rolls, etc. Back-up roll diameters are 56 instead of 53 in., and both back-up and work roll bearings are similar to the five-stand mill. Screwdowns are driven by 100-hp motors rated at 485/970 rpm. Except for length of entry conveyor, and difference in product width, details for entry equipment are identical with that installed on the five-stand mill.

Cold reduced product is recoiled on a 24-in. reel having a 1 1/16 in. collapse, and are weighed by electronic scale while still on the coil stripper buggy. Coils are then discharged onto a short pallet conveyor which delivers the coil to a tilter where the axes are rotated 90 degrees for transfer to batch annealing. The X-ray non-contact gage installed between No. 4 mill stand and the tension reel covers the ranges of 0.006 to 0.048 in. and 0.046 to 0.088 in. in order to attain maximum accuracy characteristics.

Roll coolant system installed on this mill provides optional usage of oil-in-water solution on the first three mill stands and water on the finishing or No. 4 mill stand. Equipment installed here consists of two 9600-gal storage tanks, three 2000-gpm pumps, together with strainers, filters, control valves and spray headers. One of the three pumps is utilized for boosting mill water supply to 125 psi for the No. 4 mill stand. A portion of the waste water returned from the No. 4 mill stand is discharged to the oil interception plant at the rate of about 1000 gpm, thereby requiring makeup of an equal amount to provide necessary volume for cooling. A 10,000-gal skimmer tank has also been installed for the latter function.

Lubrication systems are composed of three, plus a centralized grease lubrication system. Data on these lubrication systems are shown on Table IV.

Both cold reduction mills are equipped with individual dual hydraulic systems, one for roll balance and the other for auxiliaries. The roll balance system for the five-stand mill operates at a pressure of 2720 psi and for the four-stand mill, 3625 psi. Auxiliary hydraulic systems operate at 950 psi. Motor-pump and accumulator installation is shown on Figure 10.

Several interesting features are incorporated in the design of these systems. Stand-by pumps were obtained for each service, and are automatically activated on high demand. One static weight loaded accumulator is provided for each service, and can be cross-connected for service on both mills should maintenance requirements dictate removal of one accumulator from operation. All operating valves on the auxiliary hydraulic systems are mounted on valve stands located in the

TABLE IV

80-In. Four-Stand Mill Lubrication Systems

System	Application	Storage capacity	SSU
No. 1	Motor and motor-generator sets	4,000	295
No. 2	Pinion and screwdowns	10,000	1760
No. 3	Back-up roll bearings	20,000	1800

Figure 9 — Many of the features of the 4-stand mill are similar to those on the 5-stand mill.

basement areas and controlled through solenoid operated pilot control valves. Hydraulic lines are sized proportionately to reduce shock or hammer, and pressure losses due to fluid friction.

Fog exhaust systems for removal of steam and fumes from the mill stands are provided for both mills. These consist of two 80,000-cfm fans for each mill, together with fin-type eliminators for entrained coolant, hoods on the mill stands with down draft exhaust, and stacks for exhaust through the building roof. Fumes collected under the mill stand hoods are drawn downward through the grating and into a parallel tunnel located below pinion stands and twin gear drives. The fog exhaust rooms are arranged one at each end of the mill, and house the above mentioned exhaust fans. Relative location of eliminators, masonry walls, duct work and fans is such that condition of the eliminators and exhaust fans can be determined during operation. Eliminators can be removed from service through a hatchway, cleaned and replaced with a minimum of difficulty.

The necessity of providing adequate fire protection equipment is apparent in view of the quantity of mineral and vegetable oils in storage and magnitude of investment in these facilities. Accordingly, basement and conveyor pit areas are sectionalized into seven zones, and a centrally located low pressure carbon dioxide system was purchased for this protection. Detection of a fire in any of the zones activates the system by first sounding an alarm, then closing the necessary fire doors, dampers on ventilation and exhaust equipment, and shooting the zone with the first of two predetermined charges of carbon dioxide. Fires are quickly extinguished with 45 per cent carbon dioxide concentrations.

Intercommunication systems have been installed between mill stands on each mill, mill trains and oil and hydraulic basements, mill trains and electrical control basements, and floor and crane in the pickled coil storage bay. Intercom systems are of the frequency modulated type for high level audio.

Services other than electrical power include steam, compressed air, water and waste liquor handling. The tandem mills installation consumes a maximum of 20,000 lb of steam per hr under peak demand conditions, and is provided with 180 psi with a correspondent temperature of 530 F. Desuperheaters are installed at the steam line drop into both sections of the oil and hydraulic cellar. Compressed air furnished by three 2600-cfm compressors located in the division provides a total of 185,000 cfhr at 80 psi for the two cold reduction mills. Oil lubricators and filters are installed in compressed air lines ahead of operating valves and pneumatic cylinders. Clear water at pressures of 40 psi is also provided and is obtained from two of three wells located on plant property. Water is used for make-up of strip and roll coolant systems as well as heat exchangers on lubricating oil systems, and totals under peak demand about 2500 gpm per mill.

Cooling water from heat exchangers is wasted into storm sewers, and contaminated waters containing mineral and vegetable oils are isolated at their sources to prevent wasting without treatment. Strip and roll coolants contain small amounts of mineral oil as well as significant amounts of non-mineral oils, and the subsequent treatment of these wastes must comprehend these constituents as well as periodic volume dumping. Skimmer tanks recover a fairly concentrated oily waste which can be handled with less equipment than is required for the aforementioned rolling solution. Industrial waste lines interconnecting the rolling mills with the oil interception plant may be classified into two basic groups, one for large volume low concentration wastes, the other for continuous flow low volume high level content wastes. The oil interception plant receives in addition to these wastes, caustic disposal from cleaning lines, and spent pickling solution from the raw coil pickler and other pickling operations in the division. The primary function of the oil interception plant is to pretreat such wastes prior to secondary treatment at the terminal treatment plant and subsequent discharge to the Delaware river.

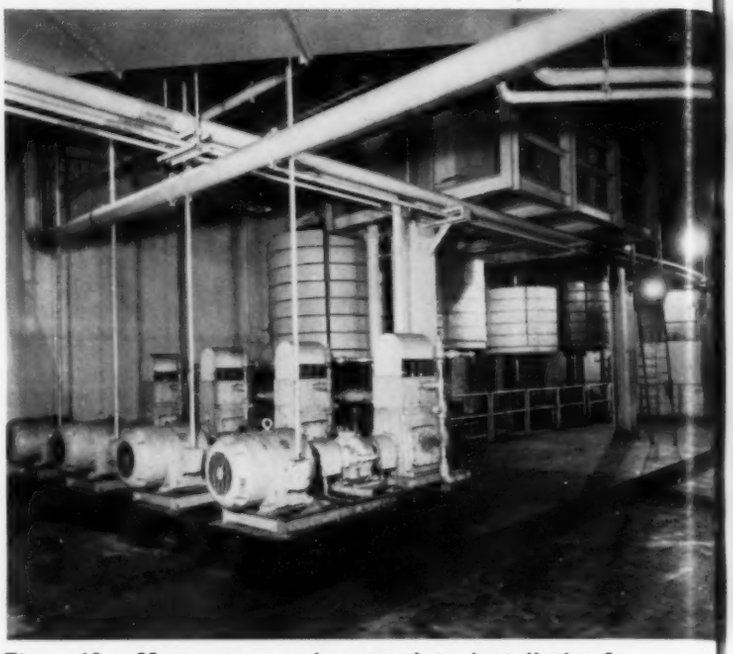


Figure 10 — Motor pump and accumulator installation for the 4-stand mill are located in the basement.

DISCUSSION

PRESENTED BY

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

A. E. CICHELLI, Lubrication Engineer, Construction and Engineering Depts., Bethlehem Steel Co., Bethlehem, Pa.

J. N. IMEL, Superintendent, Sheet and Strip Depts., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

ROBERT R. SHEDD, Design Engineer, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

B. G. BISCHOFF, District Manager, Cardox Corp., Philadelphia, Pa.

C. E. Pritchard: If I followed your trend of thought, you used about 190-psi roll coolant pressure on the five stand or 7000-fpm mill. Is that pressure range also employed on the 3000-fpm mill?

You have made direct comment about having some means of filtration or screening of the roll coolant between the pump and the spray nozzles at the mill stands. I would like to inquire as to what provision, if any, is offered in this regard between the mill stands and the receiving sump or receiving tank and from there to the pump intake?

In regard to your comments relating to the low pressure CO_2 system that you have installed for fire preventive measures, I would like to ask the question as to what happens in the event of electric power failure? Do you have some provision to permit actuation of the CO_2 system under these conditions?

Have you found it necessary to apply some type of cleaning compound to the roll surfaces on the last stand in the tandem mill rolling, such as is used throughout several mills in the industry?

On your disposal of the soluble emulsion, do you find it necessary to provide some chemical emulsion breaker or do you use the gravity separation method and skimming tray?

A. E. Cichelli: We would be interested in knowing how and where the thermocouple leads are located with respect to the babbitt material in the bearing. Have you ever saved a bearing because of this equipment? We are interested also in the lubrication of your spindles. Have you had any lubrication difficulties with them since they have been in operation?

J. N. Imel: On the temperature control for your work roll bearings, do you have a recording chart and, if so, at what position on your tandem mill is it located?

Robert R. Shedd: Mr. Pritchard raised the question concerning roll coolant pressures employed on the four-stand mill, and this can best be answered by referring to our earlier comments where it was stated that rolling solution was employed on the first three mill stands, and water on the last or No. 4 mill stand. One of three circulating pumps having a capacity of 2000 gpm is used to deliver rolling solution at a pressure of about 120 psi in the solution headers on the mill stands. Mill water is boosted by the use of one of the two remaining circulating pumps, thereby delivering clear water to the No. 4 mill stand at about 125 psi.

Another question raised by Mr. Pritchard concerned filtration of returned solution from the mill stands. Quite frequently the rolling solution contains fragments of holddown boards, scraps of metal, etc. The solution return flume is designed to prevent large sized pieces from entering the storage tanks. In addition, two large strainers are installed on the suction side of the recirculating pumps. Screens used in the strainers assure retention of comparatively large pieces of foreign matter.

With reference to method of activation of the carbon dioxide fire extinguishing equipment, I believe a representative of the manufacturer can answer that in detail.

B. G. Bischoff: We designed that CO_2 system so I think I can answer the question. On the system there are three means of operation. First of all there is an automatic means of operation which is actuated by means of heat, and consists of thermostats located in the oil cellars on the ceilings. The second means of operation is by push button stations located conveniently at points of egress from the cellar. The reason for these pushbuttons is so that the systems may be operated if a fire is detected prior to the time it takes the heat actuated devices to actuate the system.

The third means is installed for the purpose of operating the system in the event of power failure. This is the manual over-ride on the system and is operated by means of CO_2 pressure. This means consist of pilot valves located at a convenient spot considered a central point of operation. An operator can go there and operate the CO_2 system in event the other means of actuating the system are not functioning. These devices are operated by merely flipping a handle.

In the system as described, we provide double-shot protection. In other words, we have sufficient CO_2 in storage, 21 tons in this case, to cover the operation of the system twice. In other words there is a period of time after the one operation which is normally required to recharge the system, and we thus provide a second shot to provide protection during that interval. To insure that the second shot remains in storage, the system automatically determines the proper amount which is to be discharged during the first operation when actuated by either the thermostats or pushbutton station. In the case of the manual over-ride however, if it is operated by this means, the system stays in operation until the operator shuts it off or until the entire quantity of CO_2 in storage is discharged. Consequently, there are instruction plates at the manual over-ride point which are such that manual operation will also discharge only the proper amount for a fire extinguishing concentration. In this case, the CO_2 concentration was specified by United States Steel to be 45 per cent.

That generally describes the operation of the system.

Robert R. Shedd: In answer to Mr. Pritchard's last question, soluble oil is treated at the oil interception plant by the addition of spent pickle liquor in the flash mixer with subsequent sludge recovery in the clarifier flocculator.

Mr. Cichelli's inquiry concerned thermocouple location with respect to back-up roll bearings. We have elected to utilize a small reservoir in the lubricating oil return lines, feeling that oil temperature reflects actual bearing temperature in a relative sense. I think it is a case where we have learned to accept a relative indication of safe operation below which point the actual bearing temperature does not mean too much. Over a period of time we learn that a higher temperature indication will ultimately result in bearing failure, and this is the purpose and function of our temperature measuring system. Regarding lubrication of spindles, we have had no difficulty in this respect.

Mr. Imel inquired concerning temperature control for work roll bearings. We did not install temperature indication equipment for work roll bearings. The equipment secured for back-up roll bearings is located in the basement area very close to the oil lubrication basement, and is of the continuous tape record type. The oil cellar attendant is responsible for observing a trend toward increasing bearing temperature and advising operating personnel.

Returning to Mr. Cichelli's question as to whether we have actually prevented wiping an oil film bearing, I do not believe that occasion has occurred yet. In view of the relative cost of oil film bearings vs installation costs of temperature indication equipment, we feel the expenditure was justified.

By FRED S. BLOOM, President, Bloom Engineering Co., Inc., Pittsburgh, Pa.

Rate of HEAT ABSORPTION of Steel

. . . . by combining time lag and Stefan-Boltzmann's law, a practical and simplified method has been developed for calculating the rate of heat absorption and time-temperature relation . . . . its use should avoid the wastage of money in building furnaces which will not meet requirements, since no attempt should be made to build a furnace unit which calculations show are not theoretically possible . . . .

▲ THE purpose of this paper is to explain a method by which the heating rate of steel can be calculated and the center temperature of the piece predicted. Many thermal transfer problems become so involved with assumptions and undetermined factors that the average engineer has been forced to rely on "rule of thumb" approximations which experience has proven. This has led to a somewhat mysterious approach to the heat transfer problem. It is believed that the heat transfer problem can be solved with reasonable accuracy and without laborious calculation.

In this paper, will be shown:

1. Relationship of center temperature to surface temperature of a piece of steel.
2. Rate of heat transfer from furnace temperature to a black water-cooled surface.
3. Rate of heat transfer from furnace temperature to a varying steel surface temperature.
4. A simplified method of calculating heat transfer.

It is recognized that the quantity of heat transferred to the surface of material is a function of temperature difference, area of the furnace wall surface, radiating power of the flame, and emissivity of the surface of the material. This discussion will eliminate all factors except surface temperature and furnace temperature. This investigation indicates that the quantity of heat transferred follows this relationship with only a small error.

The first step in understanding the behavior of the interior of a heated piece of steel is simply explained by a paper presented by E. D. Williamson and L. H. Adams in Physical Review of 1919 which states that the center temperature of a piece of steel will follow the surface temperature of the piece by a given time lag irrespective of the rate at which the material is being heated. This statement is qualified by the provision that the temperature rise should be fairly uniform and the specific heat of the material should not change rapidly. This means that, if the time-temperature history of the surface of a steel billet or slab is known, the center temperature can be predicted with reasonable accuracy.

TABLE I

Time Lag Between Surface and Central Temperatures of Cylinders of Steel No. 5

Diam in.	1	2	4	8	16	32
Temperature, C		Seconds			Minutes	
0	3	11	46	3.0	12.2	49
50	3	12	48	3.2	12.7	51
100	3	13	50	3.3	13.3	53
150	3	13	53	3.5	14.0	56
200	4	14	56	3.7	14.8	59
250	4	15	59	4.0	15.8	63
300	4	16	63	4.2	16.8	67
350	4	17	68	4.5	18.1	72
400	5	18	73	4.9	19.5	78
450	5	20	81	5.4	21.6	87
500	6	22	90	6.0	23.9	96
550	6	25	99	6.6	26.5	106
600	7	28	110	7.3	29.3	117
650	8	31	122	8.1	32.5	130
660	9	34	137	9.2	36.7	147
670	10	38	154	10.2	41.0	164
680	11	42	169	11.3	45.2	181
Method not applicable between 680 and 780 C						
780	10	39	158	10.5	42.0	168
790	9	34	137	9.2	36.7	147
800	7	30	119	7.9	31.6	127
850	7	28	112	7.5	29.8	119
900	7	26	105	7.0	27.9	111
950	6	25	100	6.7	26.6	107
1000	6	24	95	6.4	25.4	102

It further means that if the center temperature relationship to the surface temperature is plotted, a very good observation of the temperature difference that exists between surface temperature and center temperature at any prescribed rate of heating can be obtained. In other words, if the time lag between center temperature and surface temperature is four minutes and we are heating the piece at a temperature rise rate of 50 degrees per minute, then center temperature lags behind the surface temperature by a quantity of 200 F.

Table I shows a tabulation of the time lag as expressed by Williamson and interpreted by R. Jackson and others in the British Iron and Steel Institute Publication of 1944 titled "Variable Heat Flow in Steel." The time lag shown in this tabulation is for the center temperature of cylinders. Note that the time lag is a variable, because carbon steel has a varying specific heat.

Figure 1 shows graphically the time lag variation for a specific type and dimensional piece of carbon steel. Note that in the low temperature ranges, the time lag can be expressed as 3, gradually increases to 6 at 1000 F, and increases to the point of the critical where it reaches a value of 11. In the critical range or the change point, no time lag is expressed. After the piece has passed through the change point, the time lag is reduced from 11 to a factor of approximately 6 at a temperature above 1800 F. In most heating operations, to produce steel for rolling or forging, interest is directed at the center temperature — surface temperature relationship at temperatures of 2200 F and over, because time lag determines soaking time. Thus, there is a simple system to guide one in determining the history of the center etmperature.

This system of determining center temperature by plotting center temperature in accordance with time lag gives an easy procedure to follow and is so simple that one wonders why more use has not been made of the theory.

Figure 2 is an interpretation of the time lag data expressed in Table I enlarged to show the effect on time lag of various methods of applying heat to the piece. It is, of course, realized that a piece heated from all sides has less time lag than does a piece heated from two sides or from one side.

Figure 2 shows quite conclusively why it is possible to heat a piece of steel in a very short time if all surfaces are exposed to furnace temperature in comparison with heating the same piece when only two sides are exposed or in some cases, one side exposed. For instance, in a 4-in. sq billet supported in a furnace so that it can be heated from all sides, center temperature lies behind the surface temperature by a factor of 1.6 minutes. If the same piece is heated from one side in a continuous pusher type furnace, the time lag between the bottom surface and the top surface is 12.8 minutes. Likewise, if the 4-in. square is heated from two sides, there is a time lag between center temperature and surface temperature of 3.2 minutes.

In the one case when heating from all sides, one can apply much higher furnace temperatures to the piece because very little soaking is required. The center temperature is relatively close to the surface temperature. This is what allows fast heating. A piece can be heated until the outside is ready for processing without waiting for the center temperature to reach the surface temperature.

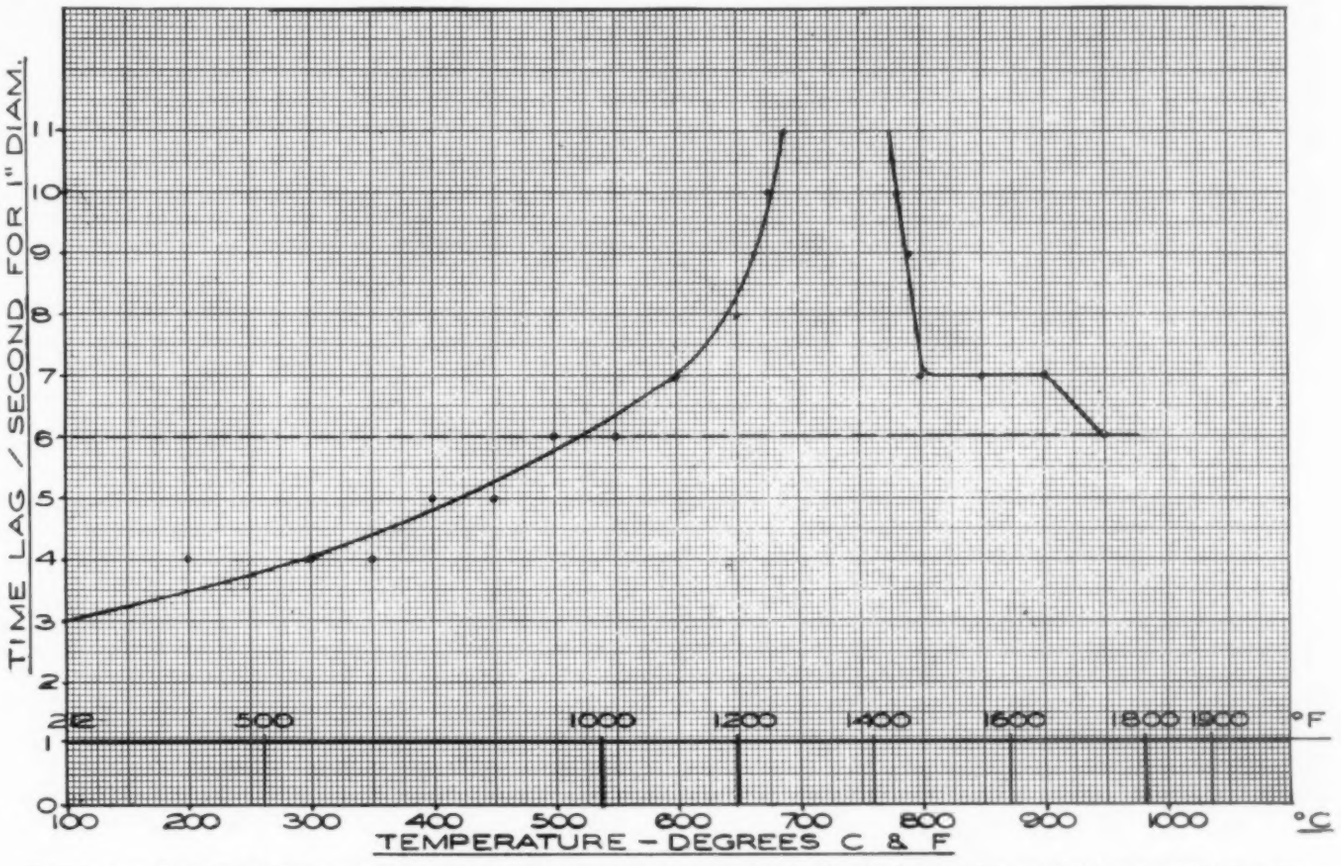


Figure 1 — Time lag between center and surface temperatures for steel cylinder heated from all sides is given by curve.

From experience a 4-in. square can be heated in a fast heating process in 8 to 12 minutes and so long as there is no need to wait for center temperature, the piece can be processed as soon as surface temperature reaches the proper value. If the same reasoning is applied to a 4-in. billet heated from the top side in a pusher type furnace, one must wait for the bottom side to come up to temperature. In other words, the top surface must be ready to roll 12.8 minutes before the bottom side. Therefore, we must do what can be called slow heating. Thus, Figure 2 gives an opportunity to see the numerical values and gives an opportunity to better understand the process by which temperatures underneath the surface follow the surface temperature. The process may have some inaccuracies, but is a simple approach to understanding the entire problem.

Size In Inches	Method Of Heating-Time In Minutes			
	Rounds	Squares	Flats	Flats
1	.10	.10	.20	.80
2	.40	.40	.80	3.2
3	.90	.90	1.80	7.2
4	1.60	1.60	3.2	12.8
5	2.50	2.50	5.0	20.0
6	3.60	3.60	7.2	28.8
8	6.4	6.40	12.8	51.2
10	10.0	10.0	20.0	80.0
12	14.4	14.4	28.8	115.2
16	25.40	25.4	51.2	204.8
20	40.0	40.0	80.	320.0
32	102.0	102.	204.	816.0

Figure 2 — Time lag is the time interval required for center temperature to reach surface temperature.

It is likewise worthy to note the time lag for heating large pieces of steel such as a 20-in. sq. ingot. The time lag in this particular case when heating from all sides is forty minutes. Should one attempt to apply fast heating to a process of this type, he must give consideration to soaking time. In other words, the piece cannot be removed from the furnace as soon as the surface temperature reaches a prescribed rolling temperature.

This figure also indicates why there is difficulty heating thick pieces of steel such as a 20-in. ingot in a continuous triple-fired pusher type heating furnace. The time lag on the 20-in. ingot is eighty minutes when heated from two sides which means that the surface temperature must be up to rolling temperature one hour and twenty minutes before the center temperature will reach surface temperature.

It likewise shows the difficulty present in heating ingots when lying flat on a brick hearth of a batch type forge furnace. Here, the piece is heated from one side or a combination of partial side heating and top heating. It indicates why it is so necessary in many cases to turn the ingot over in order to get the bottom side properly heated, because in this case, there is a soaking time of better than five hours.

This figure gives some appreciation of the magnitude of the heating problem. It indicates why thick steel cannot be heated at the same rate in pounds per square foot of hearth area as can thin steel. It explains most of the difficulties seen in all heating processes. It is interesting to note why in practice, it is possible to heat 4-in. steel in a continuous pusher type furnace from one side with no difficulty in producing a billet with a fairly uniform temperature between top and bottom surface. The time lag for this condition is 12.8 minutes.

If one tries to do this same operation with 6-in. steel, there is difficulty because the time lag between the bottom and top surface on 6-in. steel is 28.8 minutes. In other words, one must wait too long for the bottom surface to come up within reasonable equalization of the top surface temperature. Therefore, with 6-in. steel, heating is from two sides and there is a time lag of 7.2 minutes which is equal to or better than that obtained with the 4-in. steel heated from one side, but it does show that thin steel can be heated from one side without any difficulty while thick steel must be heated from at least two sides.

Figure 3 shows the investigation which was made to test the time lag theory. This figure shows the temperature history of the surface temperature and the center temperature of a 4-in. round carbon steel billet heated from all sides. The surface temperature was measured by welding the thermocouple to the surface, and the center temperature was measured by inserting a thermocouple into the end of the billet a sufficient distance so that end heating had no effect.

Note that at 300 F, the time lag is 0.5 minutes; at 900 F the time lag is 0.88 minutes; at 1200 F the time lag is 1.24 minutes. In the critical change point range, the time lag is 1.95 minutes. It gradually decreases to a point where at 2100 F, the time lag is 1.2 minutes. The time lag, as indicated by Figure 2, shows a time lag for the 4-in. round of 1.6 minutes which indicates that the experiment is reasonably accurate and the time lag theory does follow reasonably well. At least, the time lag as expressed in Figure 2 is relatively close to the time lag obtained by test in Figure 3.

Figure 4 shows the time lag relationship for a stainless steel billet. With stainless steel, there is a constant specific heat and no critical or change point to go through so a more constant time lag can be expected. This test definitely proves that the time lag theory can be used with reasonable accuracy.

The two tests were made in a furnace at approximately the same furnace temperature, and it is interesting to note that the stainless steel billet was heated as fast, if not faster, than the carbon steel billet. The center temperature on the stainless steel billet is up to 2250 F in nine minutes. The center temperature of the carbon steel billet is up to 2250 F in slightly over nine minutes. From Figures 3 and 4, there is sufficient proof to justify the acceptance of Williamson's time lag method as being satisfactory for determination of center temperature providing the history of the surface temperature rise is gradual.

It can be expected that this method of obtaining center temperatures of a piece of steel will serve no purpose if one varies the rate of temperature change of

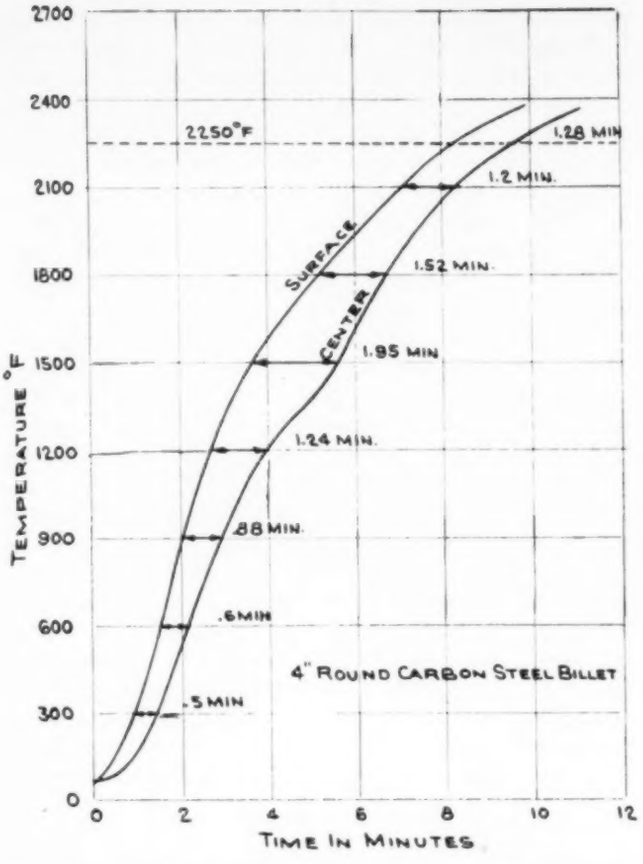


Figure 3 — Time lag test data for 4-in. round carbon steel billet.

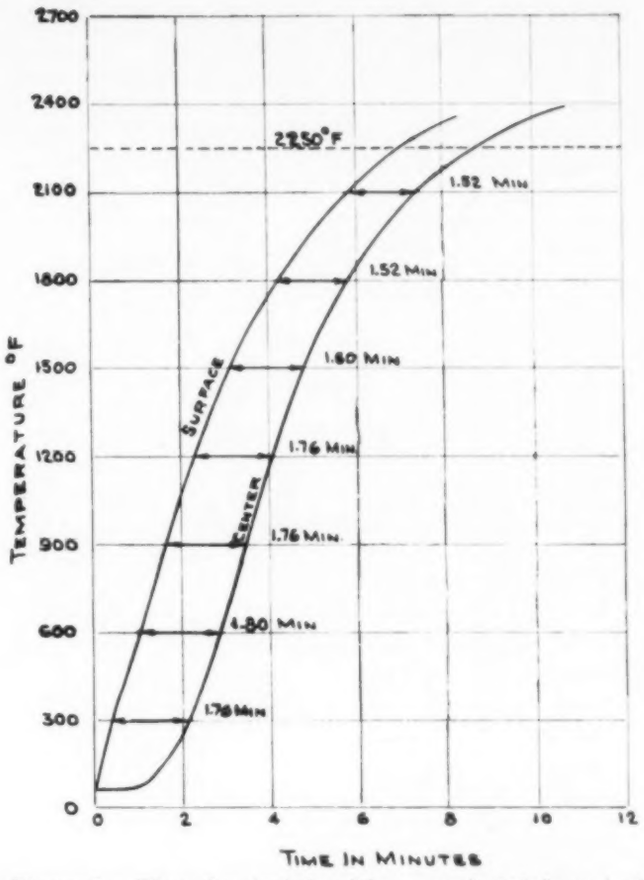


Figure 4 — Time lag test for 4-in. round stainless steel billet.

the surface of the piece radically. It will hold good so long as a fairly uniform rate of rise is carried out within the furnace. It is known from practice that increasing or decreasing furnace temperature quickly does the steel no good in the heating process.

The time lag method can be very useful in determining the time required to soak a piece of steel after its surface has reached temperature. It can be used to determine the length of the soaking zones in continuous pusher type furnaces. It is interesting to note that if this method is applied to soaking zone length in existing triple-fired furnaces that the present design is approximately correct for the steel thickness that is being heated. It likewise shows that for thick steel such as billets 14 in. and over that the soaking hearth and burner arrangement is not suitable. It explains quite conclusively why a triple-fired furnace cannot be made into a general purpose furnace. It also explains why there is difficulty when attempting to heat steels of varying thicknesses in the same time in a continuous pusher type furnace.

The time lag method indicates quite conslusively why it is possible to heat steel in a very short time if the billets are relatively small in diameter and the heat is applied to all sides. For example, a 4-in. sq steel billet has a time lag of 1.6 minutes when heated from all sides, while the same billet, if heated from two sides, has a time lag of 3.2 minutes. Thus, the 4-in. sq billet heated from all sides can be heated twice as fast as a 4-in. billet heated from two sides without obtaining any more temperature stresses due to temperature differential between center temperature and surface temperature. This has been seen in the practice of fast heating.

Likewise, it can be seen why one must "baby" some so-called critical steels. The steels are critical largely due to the fact that the heat is not applied to all surfaces of the steel at the same time. In other words, there are no more temperature stresses in a 10-in. sq piece heated from all sides than in a 4-in. sq piece heated from one side. The difficulty with stresses within the material is definitely to be a function of how the material is exposed to temperature.

In a paper given by Mr. Percy before the AISE in 1947, the time lag between center temperature and surface temperature of the steel slab measured by Mr. Percy agrees very well with this time lag method. A close study of Mr. Percy's paper will indicate that in those tests, where center temperature and top surface temperature do not agree with this time lag data, the error is probably due to the fact that the temperature in the bottom zone was lower than that in the top zone and consequently the center temperature Mr. Percy was measuring was not the true temperature center of the piece. The application of the time lag theory to practical steel mill furnace tests often show errors in steel temperature measurement which is carefully explained by Jackson in his paper on "Variable Heat Flow in Steel."

The temperature measurement of the steel surface temperature and the center temperature are difficult to accurately measure. It is believed that wherever the time lag theory does not apply, a chance for error is greater in the experimental data than it is in the time lag theory. A re-run of numerous tests using an im-

proved means of steel temperature measurement has invariably proven this to be true.

The time lag method gives a tool by which one can predict center temperature of material and know the temperature behavior of the mass under the surface of the material. The next step to develop in order to make a furnace calculation is to determine the quantity of

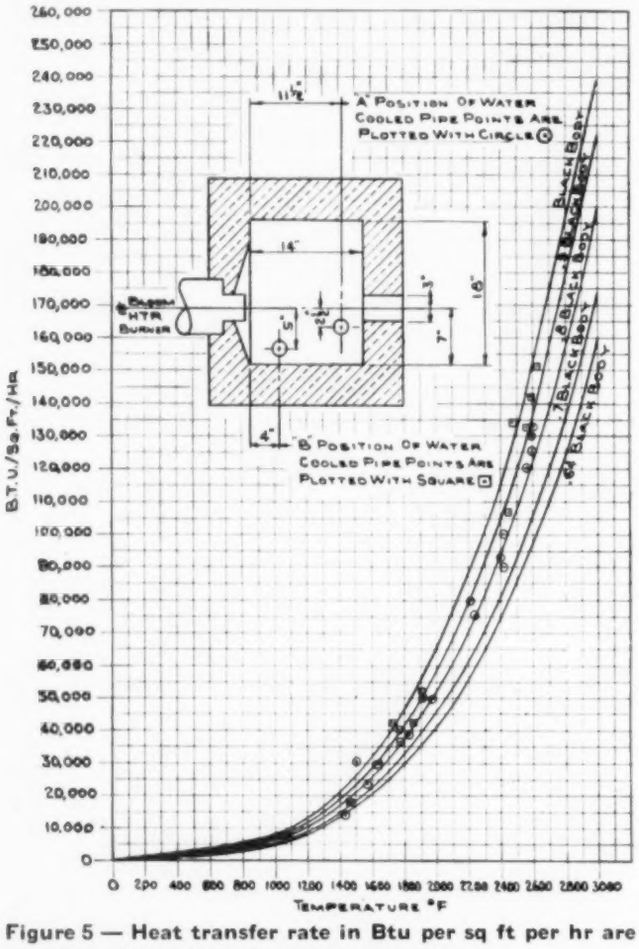

B.T.U./Sq. Ft./Hr.
Temperature °F
A Position Of Water Cooled Pipe Points Are Plotted With Circle
B Position Of Water Cooled Pipe Points Are Plotted With Square
Black Body

Figure 5 — Heat transfer rate in Btu per sq ft per hr are shown for various furnace temperatures.

heat which can be transferred from furnace temperature to a varying steel surface temperature. It is believed that this heat transfer rate can vary because of the luminosity of the flame, velocity of the flame over the piece, and the area of the wall surface exposed to radiate heat to the piece. However, for this discussion, compare four factors:

1. Furnace temperature.
2. Steel surface temperature.
3. Heat absorbed by the steel surface.
4. Heat transferred by Stefan-Boltzmann law.

Figure 5 shows an investigation which was conducted to measure the quantity of heat transferred from furnace temperature to a cold black surface. This test was conducted by measuring the heat transferred to a water cooled surface. The test mechanism consisted of a 2-in. common steel pipe with a cap welded to one end. Water was fed to the cooler through a 1-in. pipe in the center of the 2-in. pipe. Water circulated through the 1-in. pipe and back through the 2-in. pipe. The test cooler was located as shown in Figure 5.

The test was conducted at two locations to eliminate so far as possible the effect of any unequal temperature distribution within the furnace chamber. The tube was calibrated for heat transferred to the tube by the hot furnace wall by inserting the tube so that the forward end was flush with the inner surface of the furnace wall. The furnace was held at various temperatures to measure the effect of wall heat transfer to the tube. The furnace was stabilized at each temperature level to assure fair accuracy. The heat transferred to the tube was thus measured by weighing the water and measuring its temperature rise. This calibration curve was used to subtract the quantity of heat which was picked up by the tube being in contact with the furnace wall.

The tube was inserted a given distance into the furnace to expose ½ sq ft of tube area. Again, the furnace was operated at various furnace temperatures. The heat picked up by the tube was calculated by the weight and the temperature rise of the water. The calibration loss was subtracted from the total heat picked up by the tube so by difference is obtained the heat radiated from furnace temperature to a black surface.

Figure 5 shows the results of this experiment. Here is plotted the results of the experiment between lines which represent percentages of black body radiation. Note that practically all points fall fairly close between 80 to 100 per cent black body radiation. This indicates that the heat transferred to a cold surface follows Stefan-Boltzmann law to a reasonable degree of accuracy, well within the limits which can be expected with a test of this type.

This test demonstrated that the Stefan-Boltzmann law could be used for heat transfer to low steel surface temperatures; that is, temperatures up to 800 F. It was not definite that the heat transfer would continue

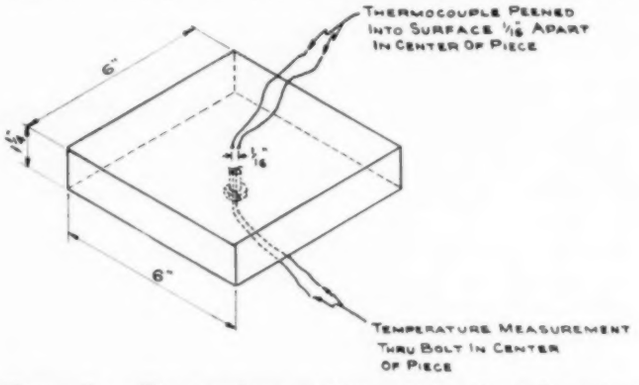


Figure 6 — Temperature measurements at center were believed to be quite accurate.

to hold good with surface temperatures in the neighborhood of 1800 to 2000 F. It was therefore decided that if furnace, steel surface, and center temperatures were measured, there would be sufficient data to check the accuracy of the Stefan-Boltzmann law with elevated surface temperature conditions.

Figure 6 shows a steel test piece which was constructed to conduct this test. The surface temperature was measured by a thermocouple whose leads were peened into the surface of the material with the leads separated by approximately 1/16 in. of material so that the surface temperature was the steel surface between the two leads of the thermocouple.

A center temperature was measured by extending the leads through a specially prepared bushing so that the two leads touched the center interior surface of a drilled hole.

Figure 7 shows a time-temperature history of this piece when heated in a furnace which was held at a temperature between 2300 and 2400 F. The furnace temperature, surface temperature, and center temperature are indicated. The time lag in this test was forty-five seconds at a temperature of 2050 F. Reference to the time lag data sheet of Figure 2 indicates that the time lag for a 1¼-in. piece heated from two sides should be eighteen to nineteen seconds. In this respect, the test is not too conclusive. In observing the time lag in the piece at a temperature range of 2200 F, there is better agreement, as the time lag at that temperature is in the neighborhood of twenty-two seconds.

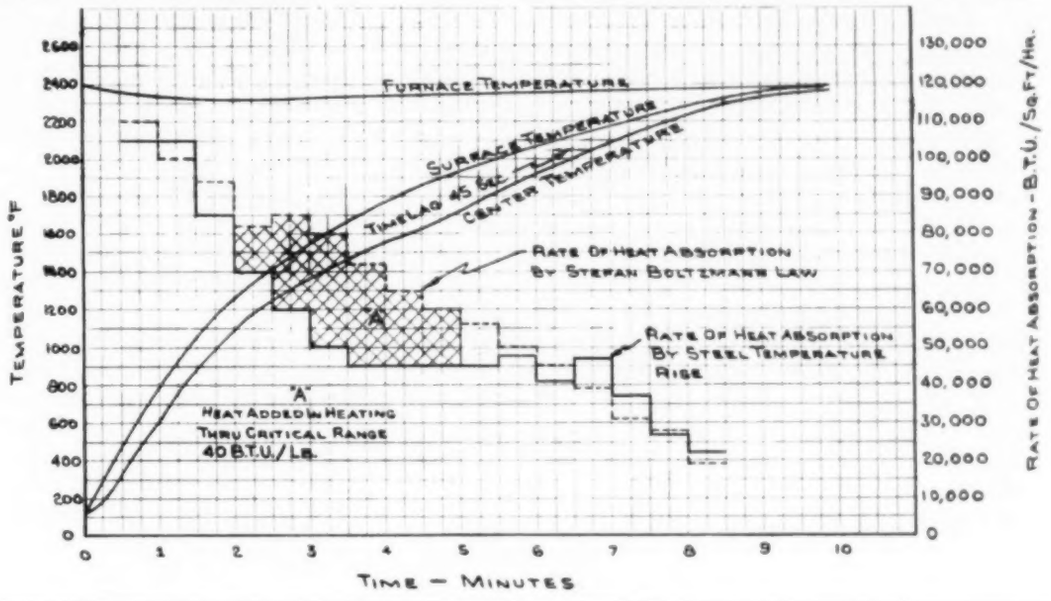

FURNACE TEMPERATURE
SURFACE TEMPERATURE
TIME LAG 45 SEC.
CENTER TEMPERATURE
RATE OF HEAT ABSORPTION BY STEFAN BOLTZMANN LAW
RATE OF HEAT ABSORPTION BY STEEL TEMPERATURE RISE
"A"
HEAT ADDED IN HEATING THRU CRITICAL RANGE 40 B.T.U./LB.
TEMPERATURE °F
RATE OF HEAT ABSORPTION - B.T.U./SQ.FT./HR.
TIME - MINUTES

Figure 7 — Steel heating test on hot rolled, oxidized steel, 6 x 6 x 1¼-in. plate was made in furnace at temperatures of 2300–2400 F.

The time-temperature history of the piece in this test was used to calculate the heat transferred to the surface of the piece. The heavy black line indicates the rate of heat absorbed by the piece at various time intervals and at various surface temperatures. The dotted line shows the heat transfer to the piece as calculated by Stefan-Boltzmann law based on furnace temperature and surface temperature.

In making this calculation for the heat absorbed by the piece, a specific heat of the material of 0.12 was used for temperatures of the piece up to a surface temperature of 1250 F and a center temperature of 900 F. Above this point, a value of 0.16 was used for the specific heat. The heat radiated to the piece was calculated using 100 per cent black body radiation by the Stefan-Boltzmann law; namely,

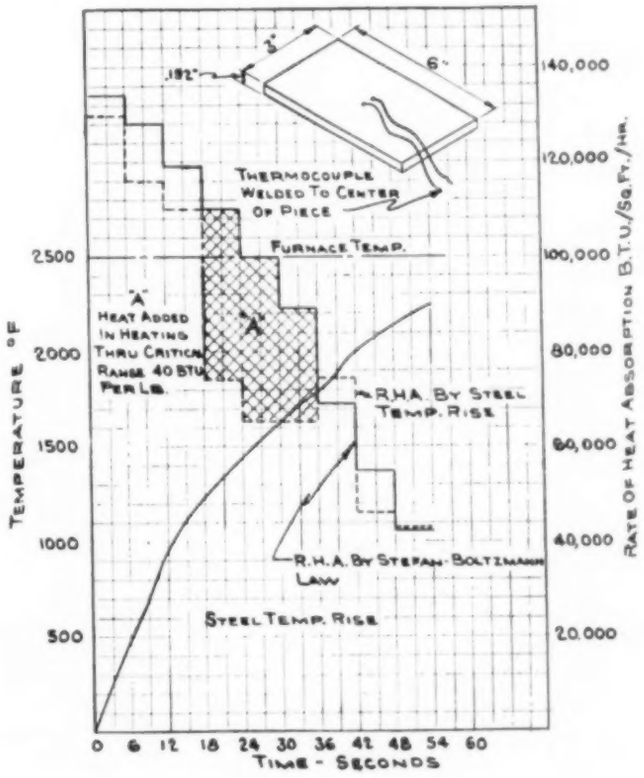
$$Q = 0.173\ (T_1^4 - T_2^4)$$

The heat transferred to the piece as calculated by the temperature rise of the piece and the heat transferred to the piece as calculated by 100 per cent Stefan-Boltzmann law refers to the scale at the right hand side of the figure. Both determinations are expressed in Btu per sq ft per hr.

A study of the relation of the dotted line and the solid line referred to rate of heat absorption indicates that there is reasonable agreement in the two calculations except where the steel passes through the critical range. Except for this portion of the test, the heat picked up by the piece follows very closely the heat which should have been radiated to the piece as dictated by the Stefan-Boltzmann law. In the calculation of the heat picked up by the steel piece as measured by the temperature rise of the piece, not taken into consideration are the 40 Btu per lb which the steel picked up when passing through the change point or critical range.

The cross-section "A" represents the total heat which is picked up by this extra 40 Btu per lb in the critical range. No attempt was made to determine at what point this heat was picked up. The total cross-sectional area represents the proper quantity. If the block "A" is filled in then there is a very satisfactory check of Stefan-Boltzmann law between furnace temperature and steel surface temperature. The relation between the dotted line representing the Stefan-Boltzmann law and

Figure 8 — Steel heating test on small 3-in. wide x 0.192-in. thick plate was similar to that in Figure 6.



the solid line representing heat picked up by the steel temperature rise falls very well within the errors that should be expected in a test of this type.

Figure 8 shows the test of the temperature rise of a thin piece of steel 3 in. wide by 1.92 in. thick. The temperature was measured similarly to the method described in Figure 6 in that the two leads of the thermocouple were inserted in drilled holes and peened to the piece. This piece was heated from two sides in a 2500 F furnace. The heavy line shows the temperature history as indicated by the thermocouple measurement. No attempt was made to determine surface or center temperature due to the thickness of the piece, and in making calculations of heat absorbed, it was assumed that center and surface temperatures were approximately the same.

The same procedure was followed in making calculations as those followed in Figure 7. The calculations determining the transfer to the surface were made at six second intervals and were based on a specific heat of 0.12 until the steel reached 1200 F and thereafter using a specific heat of 0.16. The dotted line referred to the right hand scale shows the heat picked up by the temperature rise of the steel by this calculation.

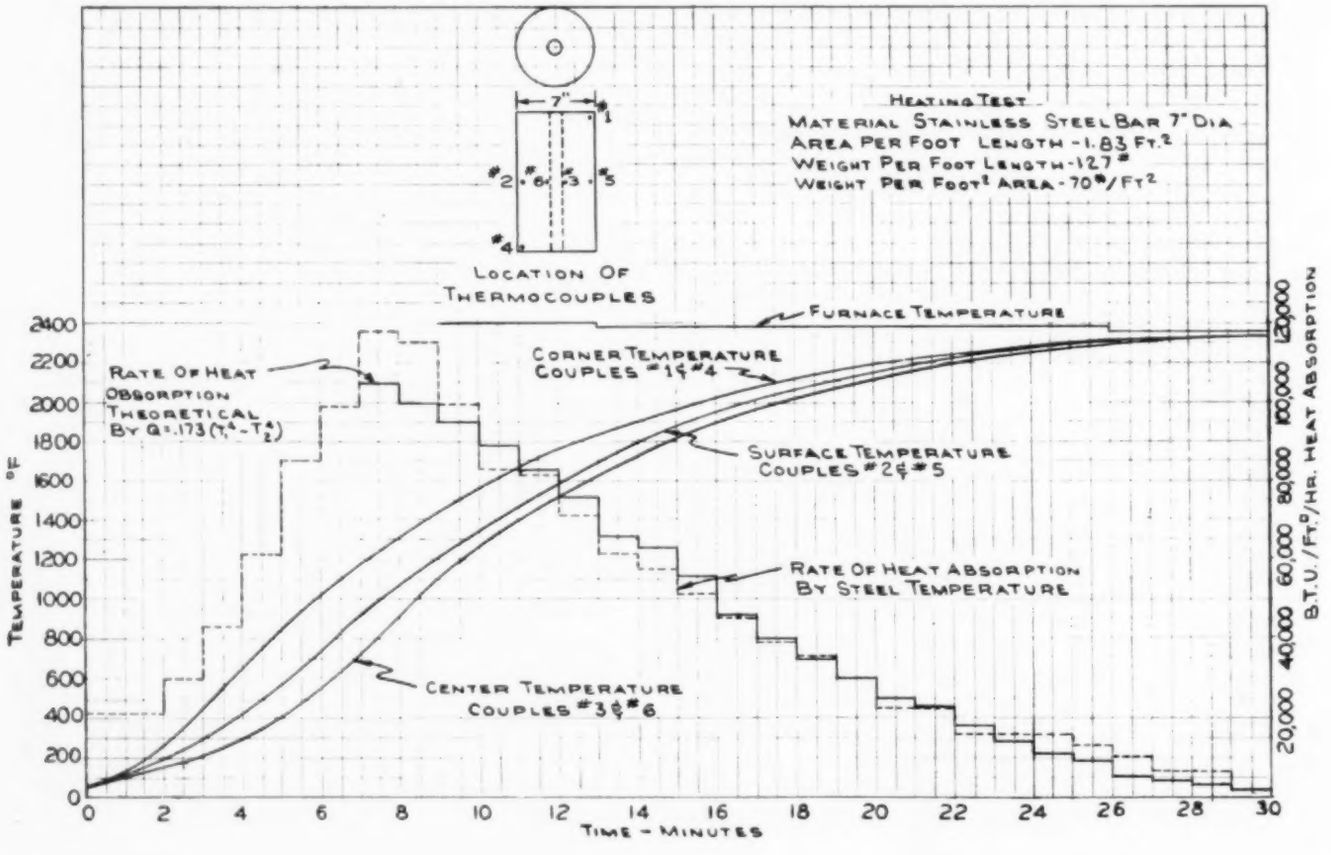
Calculations were similarly made using 100 per cent black body radiation in accordance with Stefan-Boltzmann law using thermocouple readings of surface temperature as compared to furnace temperature of 2500 F. Again, there is reasonable correlation for the heat transfer as picked up by the piece and the heat that should have been transferred to the piece by temperature difference. For example, in the twelve to eighteen second period, there are 119,000 Btu per sq ft per hr which should have been radiated as indicated by Stefan-Boltzmann law. The piece picked up 113,000. The error is thus in the neighborhood of 5 per cent, which is as accurate as can be expected.

In the range between 1250 and 1675 F, there is a large discrepancy between the heat picked up by the piece and the heat radiated to the piece. However, if the heat, namely 40 Btu per lb which must be picked up by the piece in going through the critical range is added, there is good correlation between black body radiation and the temperature picked up by the piece. The cross-hatched section "A" shows the total heat which must be picked up by the piece in going through that range. No attempt was made to show at what temperature this change takes place. It is apparent from these test results that the transfer does not take place instantaneously.

Figure 9 shows a piece tested in an industrial heating furnace. The test piece was 7 in. in diam and approximately 20 in. long. Thermocouples were welded to the piece at points 1 and 4, 3 and 6, and 2 and 5 as indicated. The material is stainless steel so there is no change point. Furnace temperature was measured by a normal thermocouple insertion in the side wall of the furnace. The material was conveyed through the furnace so that all surfaces were exposed to furnace temperature.

The time lag in this test as indicated between temperatures 2 and 6 and 3 and 5 is approximately one minute for a 7-in. diam round. When we compare this time lag to an expected time lag for stainless steel (Figure 2), it should be approximately 4½ minutes. In this respect, the test data is believed to be in error.

Figure 9 — Test data on 7-in. diameter piece of steel shows that the temperatures on the corners at the ends of the piece are 200 to 300 degrees F higher than the surface temperatures at the center of the piece.



This is probably caused by the hole drilled through the center which allows thermocouples 3 and 6 to be heated. The heat picked up by the piece based on a calculated figure of specific heat 0.16 throughout the entire range is indicated by the dash lines. The rate of heat absorption as calculated by the difference between furnace temperature and surface temperature using couples 2 and 5 as surface temperature is indicated by the solid line.

Again, there is very good correlation between the heat absorbed by the material as determined by temperature rise of the material and the heat transfer that should have taken place if Stefan-Boltzmann law holds good.

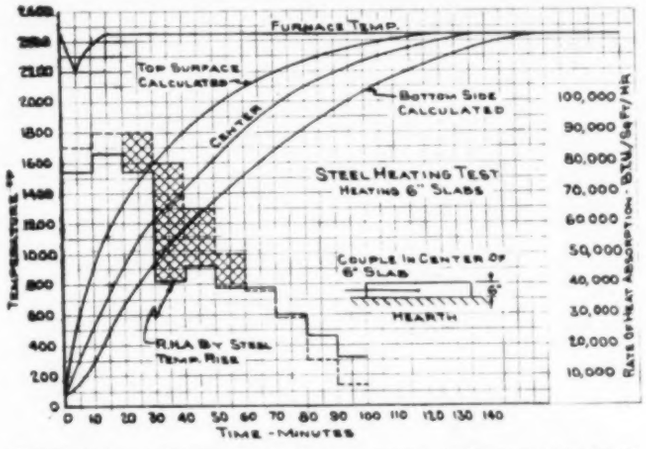


Figure 10 — Good correlation is given between the heat pick up and that predicted by Stefan-Boltzmann's law except in the range when steel is going through the critical temperature.

Attention is called to the readings of thermocouples 1 and 4 within the test piece which indicated corner temperatures. Please note that the corner temperature is approximately 200 to 300 degrees higher than surface temperature when the piece is cold. This condition exists in most instances where high rates of heat transfer are applied to the piece. It accounts for the edge overheating of strip and must be watched closely on heating any material that is not uniform in section.

Figure 10 shows a test in a steel mill furnace heating large 6-in. thick slabs. The center temperature was measured by drilling a hole on the centerline of the piece and locating a thermocouple approximately 36-in. from one end of the slab. The heavy solid line shows the temperature rise of the center of the piece. Furnace temperature was measured as indicated by a thermocouple through the backwall of the furnace. This thermocouple was situated at least 3 ft above the material. Furnace roof was 6 ft high so that the slab was exposed to a large area of interior brick surface. Furnace was fired with luminous flame burners. Surface temperature and bottom temperature were not measured during this test.

The time lag theory was used to calculate the approximate surface and bottom temperatures of the slab. If we refer to Figure 2, the time lag for a 6-in. slab heated from one side is 28.8 minutes. Thus, the surface temperature was raised and the bottom temperature was decreased according to an equal division of 14.4 minutes to both sides of the center temperature. Figure 10 shows the calculated surface and bottom side temperatures using the time lag method.

The heat absorbed by the piece is calculated by the temperature rise as indicated by the center temperature of the piece. This is indicated by the heavy black line which refers to the scale to the right hand of Figure 10.

The heat transferred to the piece was calculated using Stefan-Boltzmann black body radiation law in which furnace temperature as measured and surface temperature as calculated were used. The dash line shows the results of this calculation for heat transfer to the steel surface by the Stefan-Boltzmann law. Again, there is good correlation between the heat picked up by the piece and the heat that should have been transferred according to Stefan-Boltzmann law except for that range where the steel is going through the critical range. The cross-hatched area shows the heat which was picked up when the steel went through the critical range in total quantity. No attempt was made to distribute this quantity of heat. However, note that if the total quantity is added, there is good correlation between the heat picked up by the piece and the heat which should have been transferred to the piece.

It is interesting to note that pieces similar to the piece in Figure 10 using the same furnace, charged at the same time, were actually rolled. On one piece, rolling was tried when center temperature indicated that it was finished, approximately at 140 minutes after the piece was charged. The mill roller said the piece was not ready after trying the piece and it was returned to the furnace. Approximately twenty-five to thirty minutes later, the heater said the pieces were ready for rolling and they were rolled. This indicates that no attempt should have been made to roll the piece when the center temperature came up to rolling temperature, because the bottom surface was still cold.

From the data so far presented, it seems logical to assume that Stefan-Boltzmann law of heat transfer does follow and can be used to calculate the temperature history of any piece of steel. It is interesting to note with reference to Figures 7, 8, 9, and 10 that heat transfer rates in the neighborhood of 100,000 Btu per square foot per hour are not uncommon throughout at least part of the heating cycle. If this is transferred back into "rule of thumb" experience, it means the transfer of heat at the rate of 250 pounds per square foot of steel surface per hour which indicates that in existing furnaces, there are extremely high heat transfer rates and that the steel has the ability to absorb the heat providing the furnace temperature is available.

If Stefan-Boltzmann law of heat transfer can be used, and it is believed it can be, there is a very simple method for using such an arrangement. Figure 11 shows that black body radiation law which is constructed by solving one part of the equation; namely: $Q = 0.173 (T_1{}^4) \times 0.85$ and using the same: $Q = 0.173 (T_2{}^4) \times 0.85$ as a subtracting factor. In other words, for furnace temperature of 2600 F using the attached curve which is based on 85 per cent of the black body value, one can transfer heat to a black surface or a surface under 800 F of approximately 130,000 Btu per sq ft per hr of steel surface. If the steel surface is at 1200 F and furnace temperature is 2600 F, subtract 11,000 from the 130,000 for a differential heat transfer rate of 119,000. Similarly, if the surface temperature is 2000 F and the furnace temperature is still

2600 F, transfer the difference between 56,000 and 130,000 or 74,000. Likewise, any problem can be simply evaluated if furnace temperature is known.

The use of a chart of this type simplifies the calculation and gives the engineer a very good tool to use in judging furnace performance and likewise in making a heat pattern design. This curve indicates to the engi-

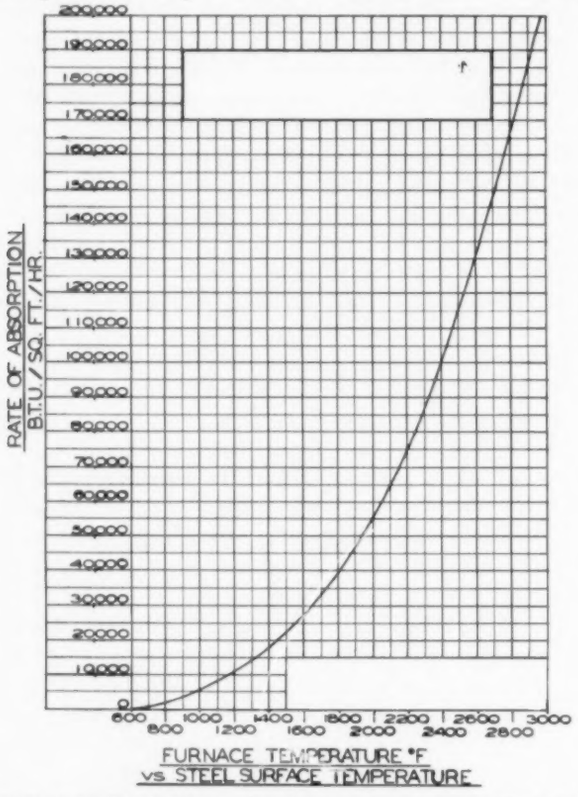


Figure 11 — Chart gives rate of heat absorption as a function of the furnace temperature.

neer the high value of heat transfer that can be obtained. In many cases in practice, the average heat transfer for a furnace is often times greatly reduced from that which this chart indicates. However, if in observing the furnace operation with particular reference to the furnace temperature, it is found that in many cases the expected furnace temperature does not exist. In many cases of continuous furnaces of the pusher type, sufficient fuel is not available to carry high furnace temperatures. In other cases, the high furnace temperature is improperly located and cannot be used, because steel surface temperature at that particular location is too high. The average heat transfer rate in many continuous pusher furnaces is less than 40,000 Btu per square foot per hour, which is equivalent to a rate of approximately 100 lb per sq ft per hr heating from one side.

In a billet heating furnace of the under- and over-firing type, a 40,000-Btu heat transfer rate to each surface of the billet should give a 200 lb per sq ft per hr heating rate for the entire furnace. There probably exists in industry today no furnace being operated under this condition. However, if the temperatures are properly located there is every reason to believe that increased heat transfer rates could be applied.

The combination of time lag and Stefan-Boltzmann law seem to indicate that by applying the two techniques, one should be able to calculate the time-temperature history of any uniformly heated piece of steel without taking too much time and with reasonable accuracy. It should be realized that if there is an error of 10 per cent, that a small change in furnace temperature can correct that error. In making calculations, the greatest difficulty comes from the fact that carbon steel in going through the critical range causes the center temperature to lag behind the surface temperature by an undetermined quantity. However, if one uses, for calculating purposes, stainless steel, one can throw out the critical temperature, and the stainless steel calculation will follow very closely that of the carbon steel. Likewise, if sufficient patience is taken in making the calculations, one can by assumption approximate center temperature by the time lag method.

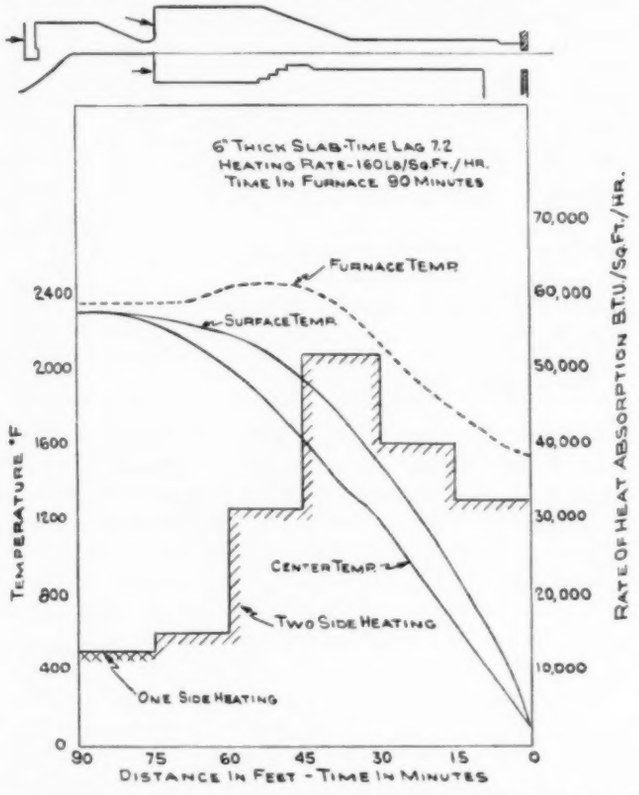


Figure 12 — Chart shows a furnace calculation for a continuous three-zone pusher type furnace.

As an example of furnace calculation, assume that there is a continuous heating furnace of the three-zone pusher type. To be found is the furnace temperature required throughout the furnace to heat a 6-in. thick slab at a rate equivalent to 160 lb per hr per sq ft of hearth area. Figure 12 shows such a calculation. In making this calculation, an ideal surface temperature rise curve has been drawn to produce a tonnage equivalent to a heating rate of 160 lb per square foot of hearth area. This means that the 6-in. slab is in the furnace ninety minutes total time.

At the top of Figure 12 is sketched a typical triple-fired furnace of 90-ft effective length so that each foot of length represents a minute in the furnace. The lower heating curve shows the center temperature rise, while the upper shows surface temperature. Surface tempera-

ture is the one drawn as being representative of what should take place on an ideal basis, and is representative of Mr. Percy's tests as presented to the AISE in 1947. The center temperature is drawn by means of time lag and corrected in the critical range to give a temperature which makes up for the heat necessary to be put in while the steel is going through the change point. The furnace temperature was then calculated based on fifteen-minute time intervals and is further based on 100 per cent black body radiation from furnace temperature to steel surface temperature. The blocked-in section shown in Figure 12 indicates the heat transfer rate required by the steel temperature rise.

The scale for this blocked-in condition is shown to the right hand side of the figure. This gives a soaking zone temperature of 2340 F heating steel to a temperature of 2300 F. The temperature in the top and bottom heating zones of the furnace is approximately 2450 F falling off to a waste gas temperature in the neighborhood of 1650 F. In analyzing this calculated temperature curve, it may be criticized that the furnace temperature is low by approximately 50 F. The exit gas temperature is lower than expected for this fast heating rate. However, one must remember in judging this calculation that equal furnace temperature to both sides of the slab are assumed. In most furnaces in today's operation, the temperature below the slab is less than the temperature above the slab; in some cases, by as much as 200 F. Therefore, if one considers all factors in heating furnace practice, one can see that this calculation is fairly representative of present day practice on a furnace of this type.

It is interesting to note the quantity of heat required in various sections of the furnace to obtain a heating rate as shown in Figure 12. Remember that 160 lb per square foot per hour heating rate is a very satisfactory heating rate for a furnace of this type. Nevertheless, in following the shaded sections (heat transfer rate) of the furnace, notice that for only a small part of the furnace is 35,000 Btu per sq ft per hr heat transfer rate exceeded, and that for a great portion of the furnace the heat transfer rate is under 15,000 Btu per square foot per hour and that this rate is obtained without exceeding a maximum furnace temperature of 2500 F. It would be a simple matter to change the furnace temperature and increase the heat transfer in this furnace. However, before doing so, it would be worthwhile to project the calculation to see what benefit is indicated. It is believed that many mistakes can be avoided by calculating temperature changes and heating rates before the money is spent to make furnace changes. Likewise, it is a simple matter to measure furnace temperature of an existing furnace operation and then to calculate the heating cycle which is obtained. It is believed that the application of the theory can lead to a better operating furnace practice.

It is possible to project this calculation to show the furnace temperature required for faster or slower heating rates. It is possible to increase the steel thickness and to study the behavior of center temperature with

Figure 13 — Chart shows calculated curves for a fast heat application on 4-in. diameter stainless piece.

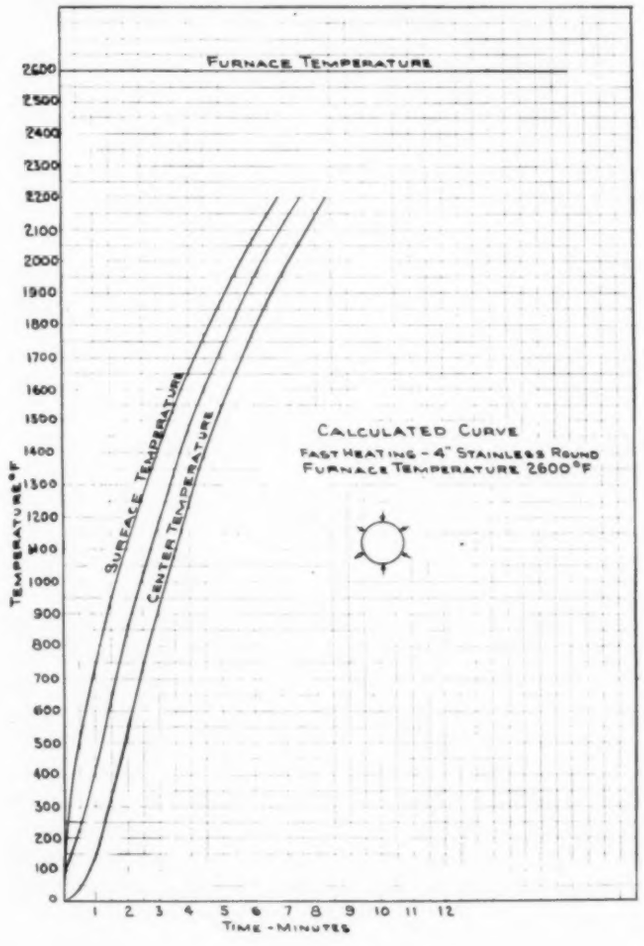
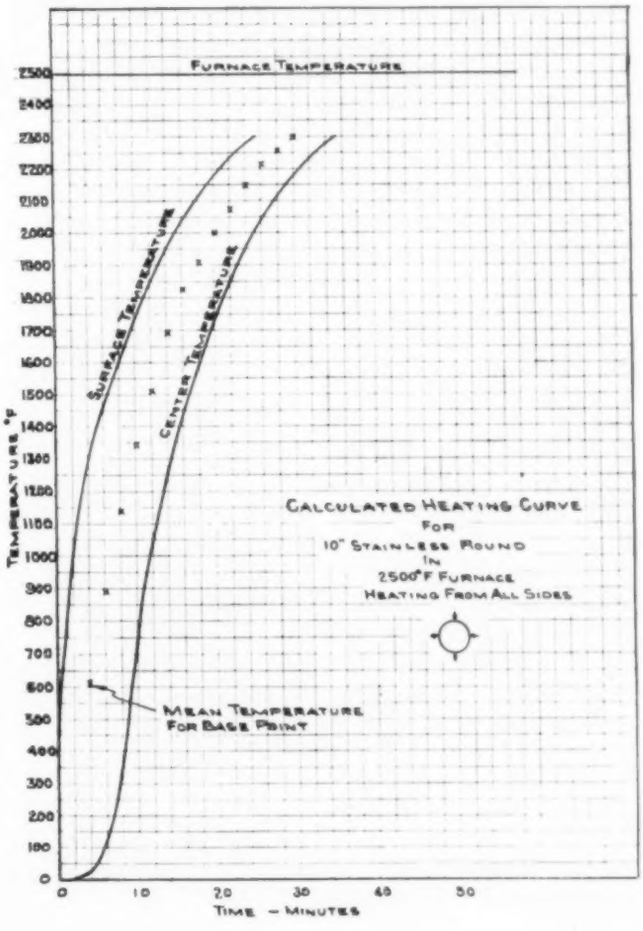


Figure 14 — Chart shows calculated curves for a fast heat application on 10-in. diameter stainless piece.



respect to the surface and the furnace temperature so that one can better understand this problem and determine what changes are necessary to make a better heating furnace.

A very interesting calculation can be made to show the heating characteristic of a furnace of the pusher type when heating thick steel in a continuous pusher type furnace. In operation today are furnaces which are attempting to heat ingots 24 in. square in a pusher type furnace. As would be expected, the surface temperature and center temperature curve, in relationship to furnace temperature, becomes quite out of proportion so that it is worthwhile to note that a furnace built for heating slabs should be changed in its heat pattern design, if it is desired to heat thick material. Calculations of this type can show very conclusively why one gets into trouble when attempting to heat thick materials in a furnace that is not designed for that material. The time lag method is a very useful tool in approximating this condition.

Figure 13 shows the application of fast heating. It shows the calculated time-temperature history of a 4-in. round stainless steel bar when heated in a 2600 F furnace. Stainless steel was taken in order to eliminate the mystery which surrounds carbon steel when it goes through the critical temperature range.

This indicates that if the piece is heated from all sides the piece can be heated in less than eight minutes in the furnace or at a rate less than two minutes per inch of diameter. This checks well with practice on heating sections of this type in a fast heating process.

Note that the method of heat transfer calculation was not changed. This curve is based on using 100 per cent black body radiation for determining quantity of heat transfer to the material. It shows conclusively that fast heating is a function of uniformity surrounding a piece with a high furnace temperature. The basic laws for time lag and heat transfer are not changed.

Figure 14 shows a fast heating process calculated to heat a 10-in. round stainless steel bar in a furnace of 2500 F. Here, there is a heating rate slightly greater than two minutes per inch of diameter. Note that the furnace temperature is 2500 F, while with the 4-in. piece it was 2600 F. Also, note the wide spread between surface temperature and center temperature. Again, this is a situation which can be accomplished and could be called fast heating, but it has not changed the heat transfer rate nor the time lag method.

The curve indicates the difficulties which are expected if one goes to extremes in any fast heating processes with steels that may be called critical, because the surface temperature is leading the center temperature in some cases by as much as 800 to 1000 F. It is possible to project this method of calculation to larger pieces of steel such as ingots.

It is suggested that this calculation be applied to such an ingot and the difficulty that exists in attempting to control the heating process is seen. In comparing a calculated curve with actual test data, good correlation is found between all factors.

The method of calculation presented gives the engineer a short-cut for determining the steel temperature and the furnace temperature required to process any proposed method of heating steel.

DISCUSSION

PRESENTED BY

H. V. FLAGG, Combustion Engineer, Armco Steel Corp., Middletown, Ohio

J. W. PERCY, Research Laboratory, United States Steel Corp., Kearny, N. J.

CHARLES F. KIRKLAND, Senior Engineer, Inland Steel Co., East Chicago, Ind.

FRANK S. SWANEY, Combustion Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

FRED S. BLOOM, President, Bloom Engineering Co., Inc., Pittsburgh, Pa.

H. V. Flagg: Mr. Bloom has given a practical treatment of the relationship which always exists between the rate at which heat can be transferred to the surface and that at which heat can be conducted from the surface to the center—whenever steel is heated. His emphasis on the point that heat application from all sides speeds up heating time and makes possible the use of higher furnace temperature, serves to explain why steel can be heated adequately in minutes under one set of conditioners where hours are required in another.

While the idea of heating from all sides is attractive in principle, in practice it is not so simple since supports and conveyors militate against even heat transfer to the bottom of the charge. In usual slab heating furnaces, where slabs are carried by water-cooled skids supported by water-cooled pier pipes, the probability is that the heat transfer to the bottom of the slab will be less than half that to the top.

A question occurs in connection with the heat transfer rate vs. furnace temperature test as shown in Figure 5. At temperatures below 1900 F, there is little to choose between the two points with heat transfer between 70 and 80 per cent black body, while at temperatures above 2500 F, the "B" position which is closest to the burners, shows higher transfer than the "A" position, approaching 100 per cent black body. It occurs to me that the considerable increase in the weight of gases required to develop the higher furnace temperature may have increased turbulence to a point where a sizeable convection transfer to the closest element would result. Such an influence might lead to confusing results if radiation is considered to be the sole heat transfer medium.

The author suggests that furnace designers might make use of the time lag idea to burner their furnaces to make use of higher temperature differences where possible, and thus get more production from a given space or from a given capital investment. As a case in point, consider the problem of slab reheating furnaces in a line where an ingot, thoroughly soaked out at 2375 F, is slabbed down from 21 to 5 in., with consequent drop to 2000 F on the top and bottom surfaces, where the strip mill requirement is for an evenly heated slab at 2350 F. The design engineer must start with guesses that are more or less intelligent when attacking such a problem, and the measure of success in mill performance will depend on the validity of the starting assumptions.

J. W. Percy: In Figure 2 of Mr. Bloom's paper, in which he indicated the time lag for both rounds and squares, heated from all sides, he shows no difference in lag between rounds and squares at the same size up to 32 inches in diameter. On small sizes this difference may be immeasurable but I would take issue with him on large sizes, above about 20 inches.

He mentioned in his paper that in some cases the time lag data did not exactly fit curves taken from a paper which I presented in 1947. I think the reason for that may be due to the fact that in my paper, the so-called surface temperatures were actually taken upon the outer scaled surface and were not true metal surface temperatures. These scale temperatures may have been as much as 100 F higher than the true metal surface temperatures, as we discovered later.

I am sorry that Mr. Bloom did not include some of his calculations in which he made use of the Stefan-Boltzmann law. In commercial or even experimental heating, we rarely find conditions where the emissivity is more than 0.90 or 0.92. Mr. Bloom's readings appear to have been made under such conditions, and yet his data fit the fourth power curve too closely for the conditions under which these data were presumably taken.

As a last question I would like to ask Mr. Bloom what kind of an arrangement was used to obtain time lag data on a piece six inches by three inches, heated from the two sides only? How did he manage to exclude the edge-heating effect on so small a piece?

Charles F. Kirkland: In Mr. Bloom's paper on the "Rate of Heat Absorption of Steel," he has done a remarkable piece of work in combining the time-lag method and the Stefan-Boltzmann law into a simplified method of calculating the time-temperature rate of heat absorption. The paper also brings out, as applied to fast heating, the importance of the manner in which the heat is applied (top only, two sides or four sides) and of the shape and thickness of the piece to be heated. With known furnace temperature, shape, thickness and the manner of heating, the tons per hour can readily be calculated with close accuracy.

The time-lag method brings out clearly the trouble we are encountering in having 3-in. thick slabs followed by 4-in. to 6-in. slabs and back again to 3-in. slabs through the same furnace. The 3-in. slabs are too hot and the 6-in. are too cold. I do not know of any remedy for it except to have a furnace for each thickness to be heated.

I see no reason why this same method would not apply in some degree, to heating ingots in soaking pits. I would like to ask Mr. Bloom if he would comment on this.

Frank S. Swaney: Any thought provoking paper such as this cannot but help raise some questions in the reader's mind. Three such questions are as follows:

1. It was noted that the dimensions of the test furnace used in Figure 5 to determine the heat transfer to a cold black surface were such that the furnace wall area to stock area ratio was about 18 to 1. Although no furnace dimensions are given for any of the other tests, it is felt that something near this same ratio of wall to stock areas must have been used inasmuch as the furnace temperature showed no drop when the sample was introduced into the furnace. It is our understanding that under conditions of high wall area to stock area ratio, the rate of heat transfer to the steel is determined almost entirely by radiation from the furnace walls. The stock "sees" so much more wall radiation than anything else that it is the controlling factor. However, industrial reheating furnaces, utilizing maximum hearth coverage as they do, are usually designed with wall to stock ratios of 2 to 1 or less. Under this condition, it is possible that radiation from the flame itself may play a much more important part in the total heat transfer than under the first condition.
2. Referring to the furnace calculation for a triple zone fired heating furnace shown in Figure 12, the calculation is based on equal furnace temperatures in both the top and bottom heating zones. This is not always possible. In fact, Mr. Bloom refers to possible temperature differentials as high as 200 F. Some of the contributing factors to such a discrepancy are:
   a. Water cooled skid pipes and supports in this bottom zone area extract an appreciable fraction of the total heat released. A conservative figure for this may be 10 per cent of the total furnace fuel which means better than 20 per cent of bottom zone fuel input.
   b. Although it is thus necessary to develop in the bottom zone 120 per cent of the top zone heat release, the bottom zone usually has less than 50 per cent of the combustion volume available in the top zone. This condition is usually aggravated by slag buildup. It would seem, however, that Mr. Bloom's calculations could be modified to take care of any such lower bottom temperature.
3. Mr. Bloom mentions that it is possible to increase the furnace heating capacity above that shown in Figure 12 by raising the furnace temperature. Would that be done by raising the general temperature level along the entire heating zone or by locally raising the temperature at the charging end where the heat transfer rate is the lowest? If the latter case is preferred, would that entail additional burners along the side or at the end of furnace?

Fred S. Bloom: Mr. Flagg has been very generous in his remarks in that he has agreed with most of the points which we tried to bring out in our paper. He questions the test data shown on Figure 5 where we attempted to measure the rate of heat transfer to a black surface by means of measuring the heat picked up by water cooling that surface. Mr. Flagg brings out that part of the heat transfer may have been caused by convection. It is my belief that in all heat transfer problems, some of the heat is transferred by convection. What we have attempted to bring out in our paper is that the total heat that is transferred to the surface, whether by convection or by radiation, follows Stefan-Boltzmann law with reasonable accuracy. It is my belief that we become too theoretical when we try to designate a percentage to convection and another part to radiation. So long as we know what the total is, we ought to be at least partially satisfied.

Mr. Flagg presents a problem for calculation and then shows how difficult it is to solve the problem even though we know what the heat transfer would be, because there is no good base from which to start the calculation. If there is no good starting point, the only method of solution is one of constructing an experimental test unit by which the final result can be obtained, and after this has been accomplished, the original basis can be calculated from the foregoing data. There are very few problems that cannot be solved providing some experimental work can be done.

Mr. Percy questions my statement that rounds and squares have the same time lag. In this respect, it may be true that there is some difference. Our investigations indicate that the time lag is the same and that a 2-in. round bar or a 2-in. square bar can be heated with the same spread between center and surface temperature.

Mr. Percy also questions my arithmetical calculations to show that the test data follows the Stefan-Boltzmann law. We agree with Mr. Percy that our calculations follow Stefan-Boltzmann law almost too closely. However, one of the reasons for our calculations checking Stefan-Boltzmann law so closely is because of our method of steel temperature measurement. In our original investigations, which were conducted eight or ten years ago, the test data did not fit, and it was only in our latter work, the success of which made this paper possible, that we were able to measure steel temperature rise with sufficient accuracy to prove our case.

Mr. Percy also questions the accuracy of test Figure 8 where a thin piece of steel 3-in. wide by 6-in. long was investigated. He believes edge heating would affect the temperature measurement. I witnessed this test, and we did obtain edge heating, but the edge heating that occurs is a very narrow band surrounding the piece, and it does not affect the thermocouple which is welded to the center of the piece. We get edge heating when a piece is exposed to a high temperature furnace. It is our opinion that even though edge heating occurred, it did not influence the temperature rise of the center of the piece.

Mr. Kirkland asks why the application of this calculation could not be made to heating ingots in soaking pits. This method can be applied to soaking pits. However, we must realize that the average soaking pit does not provide a uniform temperature to all surfaces of the ingot. Most pits are hotter on the top than they are on the bottom, or they are hotter on the front side of the ingot than they are on the back side, so that we can make calculations, but they will do us no good until we find a way to surround our ingot in a soaking pit with a uniform furnace temperature.

If we can surround an ingot with a uniform furnace temperature, a 24-in. square ingot could be heated from cold in one-fourth the time it takes under present conditions. In other words, one of the reasons why we have to soak our steels is because we do not have a furnace of a uniform temperature. In practice, we do not need to soak our steels so much as we need to soak our furnace. The steel becomes uniformly heated when the furnace becomes uniform in temperature.

Mr. Swaney brings up another part of the heat transfer problem and that is wall area to metal surface area. It was not the writer's intention to cover all phases of industrial furnace design in this paper. I believe we all will agree that the area of the source of radiation plays some relative part to the area of the receiving body. We have made no attempt to explain all of the factors that are necessary to design a furnace. Most of the test data was taken in furnaces heated by clear flame combustion where we had radiation from the walls and some radiation from the gases. We have not attempted to show the effect of radiation from luminous flames. That is a very controversial subjet in itself. However, Mr. Swaney's remarks are one of the reasons why luminous flames play an important part in the heating process of those furnaces where the radiating wall area is a small ratio to the receiving steel surface area.

Mr. Swaney questions that if the furnace heating capacity were to be increased over that shown in Figure 12, should it be done by raising the entire furnace temperature level or should it be done by increasing the furnace temperature locally in the charging end? I have not stated a position as to the best method for increasing furnace capacity. The paper, as presented, gives us a method of calculating what can be done if the furnace temperature is changed. The wisest plan would be to make a series of calculations. In other words, we can make a calculation with the furnace temperature increased by 200 F at the charging end. This will change the heating curve and give us a definite result. We can likewise change the furnace temperature in the middle of the furnace, and that will give us another calculated result. We can change the furnace temperature in the soaking zone and that calculation will give us a different set of conditions. It is my opinion that all factors should be studied. The method of calculation is available. Perhaps the best method of approach to solving the problem of greater capacity is to calculate a new furnace temperature using the surface and center temperature curves as exist in Figure 12, but changing the time in the furnace from 90 minutes to 70 minutes. Thus, we change the heating rate from 160 lb per square foot of steel surface per hr to approximtely 200 lb per sq ft of steel surface per hr.

In conclusion, it is my opinion that it is best to calculate improvements before money is spent. Too often, money is waisted on "white elephants" which would never have been attempted had calculations been made. I know of one case where considerable money was spent to raise the surface temperature of a hot billet 200 F in a very short time. The actual temperature rise was less than 5 F when the job was tried in practice. Had a calculation been made, the structure would never have been built, because the job was impossible from a theoretical standpoint.

If we cannot calculate a job theoretically, we better not try to do the job in practice. Our theory should indicate how close we are to being right. Too often, our furnace problems contain items of mystery, part of which is caused, as Mr. Flagg brought out, by not having a good foundation on which to start a calculation. Others are caused by our lack of theoretical knowledge which we have tried to correct in this paper.

Methods for Locating Faults on electrical cables

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. . . . there is no single scheme which will locate all types of faults in different types of cable . . . . with ingenuity, the various schemes described can be used to locate practically any fault . . . . it is desirable to have cable systems mapped and identified, and to have men familiar with the cable systems and with the methods used for locating faults . . . .

▲ ELECTRICITY plays an ever increasingly important role in the operation of a modern steel mill. An interruption of power to a strategically located item of equipment may result not only in outage time for the particular machine effected, but also in the idling of additional men and machines entailing a further loss in productive capacity. If the fault locating procedures and methods are inadequate for the task, the outage time may be considerably increased over that required when efficient methods are employed in an orderly manner. Thus the necessity for utilizing methods that will rapidly disclose the cause and location of power failures need hardly be emphasized.

There are a number of items that should be considered prior to the occurrence of a failure. An intelligent analysis of these items will add materially to the ease with which a fault may be located. These include knowing the equipment, obtaining maps and records of the cable system, and providing for field identification of the cables by a plan of tagging. This paper will give a discussion of the safety aspect in locating failures in the hope that accidents may be avoided. Following this is presented an outline of the fault types to be encountered; the methods that may be used to analyze the fault condition; and several methods for reducing the fault resistance by carbonizing procedures. Finally, the various schemes that are available for locating faults on electrical cables are critically examined.

KNOW THE EQUIPMENT

One of the primary requisites for successful fault location is to be thoroughly conversant with the equipment that is available. This means that the operator should be sufficiently proficient with the equipment so that its operation becomes second nature and he may then devote his total energies to the problems associated with the field location of the fault. This seems an almost obvious requirement, but it is surprising the number of times that an operator will be called upon to locate a source of trouble and then must spend additional time familiarizing himself with the operation of the set. For a new piece of equipment, staged fault tests should be carried out until the operator becomes proficient with its performance and application. The time and slight inconvenience involved will be more than amply compensated for when an actual case of trouble is encountered. Several operators should be trained to handle and use the equipment if this is possible. Failures are notorious for occurring at inopportune times, as when the regular operator is sick, absent from the plant, or is elsewhere engaged in activities limiting his immediate availability.

MAPS AND RECORDS

Accurate maps and records of the cable system are another valuable adjunct in rapidly ascertaining the location of a cable failure. This is especially true if the fault locating methods are dependent on the application of any of the measurement schemes. They will also prove valuable in eliminating guesswork as to the route of cables and in determining suitable "halving" distances when tracing current schemes are used. While it may not be considered necessary to maintain this information for short apparatus circuits, it is thought that such information pertaining to the main transmission and distribution feeders is essential.

The office records may be very elaborate showing the number and location of cables in a duct line or conduit run, the route of the duct line, conductor size, insulation thickness, type of cable, the manufacturer of the cable, date of manufacture, etc. This information is valuable in planning construction or maintenance work, but may become too onerous and expensive to continue.

There is, however, a definite need for up to date maps for use in locating failures. These maps should contain a minimum of information necessary for the job, be suitable for carrying into the field, and should be capable of easy duplication or replacement. Information contained thereon should include: The route of the cable including location of taps, switches, etc., voltage rating of the cable and changes in cable construction or size. It is also helpful to allow sufficient blank space on the map that the operator can make notes and diagrams while tracing the failure. If the maps are to be used in conjunction with measurement techniques, additional data in the form of pre-calculated equivalent circuit lengths is desirable.

The maps and records should be maintained as simply as the extent and complexity of the cable system will permit. The system adopted should provide sufficient flexibility in records that future growth of the cable system can be easily accommodated.

Many systems have a substantial amount of cable installed for which accurate maps and records are not available. If the system is at all extensive, the process of assembling this information may prove to be unduly expensive. Under this condition the detail and accuracy of the existing records may become a factor in the selection of fault locating methods to be used on the system.

CABLE TAGGING

Rapid field identification of faulted cables is further enhanced by an orderly system of cable tagging. The individual cables in each manhole or junction box should be permanently identified with the cable as shown on the operating map by means of a suitably inscribed marker fixed to the cable. The tag should be made from a non-deteriorating material that is legible under severe conditions of encrustation or discoloration. Many companies have found it advantageous to indicate the nominal operating voltage of the cable as a part of the system of cable identification. For individual apparatus circuits emanating from switch boxes, a card literally describing the circuit has been found to suffice.

SAFETY

Before attempting location work on a de-energized faulted cable, all conductors should be checked for the absence of voltage. This may be done with a lamp, voltmeter, or any of the commercial potential indicating devices. The device should be tested on a live circuit both before and after the check is made on the de-energized circuit in order to eliminate the possibility of using a malfunctioning instrument and the hazards attendant upon its use.

Any possible points of backfeed on the circuit should be rendered inoperative or be conspicuously tagged to avoid exposing the operator to the danger of an unexpected potential through accidental energizing of the circuit. Rubber gloves and leathers, though sometimes considered a nuisance, are extra safety insurance for any operator doing fault locating work.

After a cable has been energized with a high voltage direct current, it should be solidly grounded to discharge the shunt capacitance before attempting any work on it. The ground should be left on a sufficient length of time to prevent the reappearance of voltage due to the effects of dielectric absorption.

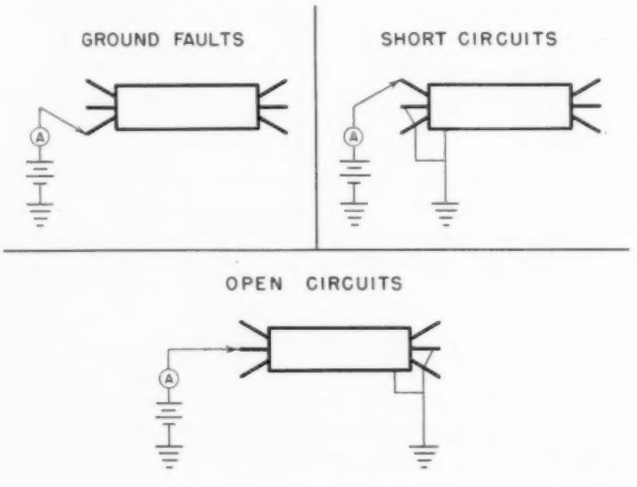
While dealing with the safety aspect of fault locating procedures, mention should be made of the hazards to be encountered in manholes. Manholes act as collecting points in which gases from minute leaks may accumulate to the extent of becoming sufficiently concentrated to pose a serious risk to any person entering them. It is a wise policy to check every manhole for the presence of gas before entering it and to continually monitor the conditions while working in a manhole. If gas is present, adequate ventilation must be provided to dilute the concentration of gas in the manhole to a tolerable level.

A further safety practice worth observing is that of spudding a cable with a sharp pointed spear after the failure has been located and repair work is about to commence. This procedure provides protection for the splicer against errors arising from accidentally energizing the cable or from incorrectly identifying the faulted cable during the interim between locating the fault and starting repair work.

TYPES OF FAULTS

Insofar as fault locating practices are concerned, the various types of failures may be resolved into ground faults, short circuit faults not involving ground, and open circuit faults. Faults may involve just one conductor in the cable or they may involve all the conductors. There is the further likelihood of having more than one type of fault, e.g., two conductors may be shorted and grounded, or one conductor may be burned open with a second conductor being grounded. However, the possibility of various combinations should not be extended too far, as most of the combination faults

Figure 1 — Three types of faults in cables are illustrated in this sketch.



may be treated and located as one of the three simple types.

Any of the foregoing fault types may be further classified according to the resistance developed across the failure. It is not uncommon to have low resistance faults occur when the failure takes place while the cable is in service. Cable faults that occur during the process of high voltage proof testing frequently have a high resistance characteristic. Small conductor cables subjected to flexing, conductors subjected to the imposition of a heavy stress, or cables on a high short circuit capacity system are liable to develop open circuit faults.

ANALYSIS OF FAULTS

An analysis of the fault condition should be made to ascertain whether it is a ground fault, a short circuit, or an open circuit and to obtain as much additional information as possible. It is best to proceed in an orderly manner, though for cables having a relatively few conductors, the following procedure can easily be shortened. Grounded conductors are most readily identified by opening the far end terminations and clearing the conductors from the ground and from one another. Voltage is then applied between each conductor and ground at the test end and a suitable detector as a lamp or ammeter is used to determine a ground by indicating a flow of current. A commercial high reading ohmmeter is frequently used for this purpose.

Short circuits are found in a similar manner with the far ends open circuited. All conductors are then tied together save for one conductor. Voltage is applied between the bundled conductors and the one test wire. Any one test wire indicating a flow of current is tagged and returned to the bundle. All others are withdrawn, one by one, until only the shorted conductors remain in the bundle.

Open conductors are easily found by tying all the far end conductors together and to ground. Voltage is then applied between each conductor and ground. The failure of a conductor to pass current indicates the presence of an open circuit. If a faulted circuit does not indicate the presence of grounds, short circuits, or opens, suspect that an open may exist in one of the branches whose far ends are not tied together.

In using these tests, particular attention should be paid to removing all apparatus including meters, instrument transformers, etc., from the circuit or misleading results will be obtained. If alternating current is used, special attention must be afforded the effects of charging current or false indications may result on long cables having a large amount of distributed shunt capacitance.

If measurement schemes are to be used, it is necessary to obtain some idea of the fault resistance in order to determine the most applicable method. This may be accomplished by using a direct reading ohmmeter of the "megger" type. If any variation of the Murray loop scheme is contemplated, the resistance of the loop should be measured and checked against the resistance of known or calculated loops to ensure that a partial burn through of the conductor has not inserted some series resistance. With large conductor sizes, a small series resistance will introduce a considerable error in locating the fault. The measurement may be made using a Wheatstone bridge or a low range direct reading ohmmeter of the "ducter" type.

CARBONIZING PROCEDURES

Most fault locating schemes produce better results when the fault resistance is reduced to as low a value as possible. This may be accomplished if a high voltage transformer can be made available for carbonizing, using reactors to limit the output current should the fault resistance become suddenly lower. A constant current street lighting transformer may also be used for this purpose. In either case, the required size of transformer may be excessive due to the amount of reactive current required for charging the cable. This limitation may be overcome by using a step-up transformer in conjunction with a high voltage kenotron or thyratron tube to rectify the alternating current. Either voltage control or current limiting resistors should be used to protect the tubes from plate dissipation in excess of their ratings. As a last resort, burn down may be accomplished by energizing the cable through a station breaker. This is not recommended though as it subjects the system to repeated transient high voltages; imposes an added duty on the breaker when interrupting the fault current; may result in damage to adjacent cables from the arc energy liberated at the fault; and may not be successful in carbonizing the fault, but only in producing further burning of the cable.

METHODS FOR LOCATING FAULTS

There are two basic schemes in general use for locating a point of breakdown on an electrical cable. The first mentioned scheme employs equipment that will measure the changed characteristics of a faulted cable.

The second scheme employs equipment that imposes an electrical signal on a faulted cable which is used for tracing along the circuit until the point of failure is reached.

Before becoming too engrossed in descriptions of the various measurement and tracing schemes, mention might be made of two of the earliest schemes used for locating failures.

Visual inspection—The first method consists of conducting an inspection of the cable route. It may be possible to locate the failure by a visual inspection of all manholes and junction boxes immediately after the failure has occurred. Inspect all joints for signs of swelling or splitting. The cable should be observed for burns, especially at the duct mouth or other locations where the cable is subject to wear. Observation of smoke or the presence of a burned smell may also help to locate the failure. If the cable circuit is short, reasonably exposed to view, and a plentiful supply of help is available, visual inspection may sometimes produce rapid results by stationing men along the circuit and re-energizing the cable. The possibilities of attaining success with this method should be carefully weighed against the disadvantages of energizing a faulty cable as previously listed under carbonizing procedures. The men should be stationed so as to be clear of any possible danger when the faulted cable is energized. The current

should be limited in magnitude by using a reactor, a water resistance, or by placing a quick blowing fuse in series with the faulted conductor.

Cut and try—The other early method used for locating faults is aptly described as a "cut and try" process. This method consists of cutting through the faulty cable at its midpoint and then testing either end for the presence of the fault. The end indicating the fault is then halved, cut again, and retested. This process is continued until the fault is isolated in one section. The method is time consuming and expensive, requiring six to eight cuts for long cable runs, with the necessity of remaking good joints. The cut should be made through the center of a joint so that the cable can be respliced without introducing extra joints into the cable. The method is worth noting as it will produce results when all other methods fail. For small cables or short cable runs its use may sometimes be justified, but the method should be applied systematically with little reliance placed upon guesses estimating the possible location of the failure.

MEASUREMENT SCHEMES

Measurement schemes generally require a thorough knowledge of circuit constants and configurations, a greater degree of skill in manipulation and understanding of the theory of operation for their successful application, are more subject to errors, and require access to all terminations of the circuit. They may utilize measurements of resistance, capacitance, or time of transit of electrical signals.

Resistance measurements—There are several bridge methods available for locating grounds or short circuits by measuring conductor resistance. They are generally used where there is at least one unfaulted conductor in the cable to make a return loop. Barring this requirement, the methods may still be used if temporary conductors are strung in such a manner as to permit forming a continuous loop. Special adaptations permit the use of bridge methods where all conductors are shorted but continuous although these methods introduce approximations in the balance equations.

a. Murray Loop.

The Murray loop can be used for locating low resistance grounds or short circuits on power cables if the fault resistance is low enough to allow sufficient bridge current to flow such that a sharply defined balance point is determinable. The method is a modification of the Wheatstone bridge with two of the legs formed by a resistance slide wire (or a set of resistance coils) and the other two legs being formed by the faulted conductor and the good conductor connected in series at the far end of the loop. A battery or other source of direct current is connected between ground and the movable contact on the slide wire. The bridge is balanced by adjusting the sliding contact until a galvanometer across the resistance legs shows no deflection when current is flowing through the battery circuit. The ratio of the resistance readings of the bridge legs is then proportional to the fault distance.

There are several points of importance to be emphasized when using the Murray loop test. All far end terminations of the circuit must be cleared before proceeding with the test. The resistance of the cable loop should be uniform throughout its length. If not, the lengths of different sized conductors should be converted to equivalent lengths of the lowest resistance conductor in the loop. The far end connection of the loop should preferably be made by clamping the conductors together, being careful to avoid point contacts. If a jumper wire is used at the far end of the loop, it should be equal in resistance to the conductor or alternatively be converted to an equivalent length. Once the fault location has been established in terms of length of equivalent conductor, final field location of the fault must be made by the process of reconverting back to actual lengths.

The presence of stray currents or of galvanic voltages at submerged faults present no difficulties as they are in the battery arm of the bridge and their effect will disappear when the bridge is balanced. The only possible sources of residual deflection arise when there are two or more faults in the cable permitting the flow of an unbalanced circulating current; when the cable has been previously subjected to a direct current voltage and this charge has not been fully dissipated; or when currents are induced from adjacent circuits. Under these latter conditions balance to a false zero is possible if the residual deflection is constant.

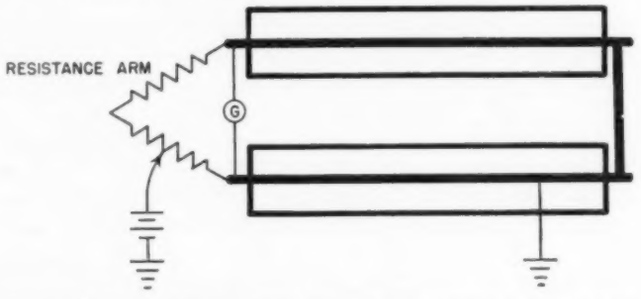


Figure 2 — Low resistance grounds or short circuits can be located with the use of the Murray loop, a variation of the Wheatstone bridge.

Errors due to lead wire resistance may be overcome in either of several ways. The bridge may use special leads which have been previously calibrated as composing part of the slide wire resistance. The galvanometer connection is then made at the conductor termination rather than at the bridge terminals. With this connection it will sometimes be impossible to locate a fault near the bridge end of the loop without reconnecting the galvanometer and making additional corrections. Alternatively, the resistance of the leads may be accurately known, but they do not function as part of the resistance legs of the bridge. With this method the errors due to contact resistance may be minimized by placing the contact resistance on the same side of the galvanometer as that part of the bridge circuit having the greater resistance. The disadvantage with this method lies in the additional calculations necessary to convert to the equivalent resistance of the conductor.

The analysis of temperature variations along the cable route presents a great many complications and under most circumstances no attempt is made to correct the conductor resistance for these variations unless there is known to be a pronounced variation and definite information is on hand.

Errors arising from the presence of suspected ther-

mal electromotive forces may be compensated for by reversing the battery connection and averaging the readings. A worthwhile check on the accuracy of the bridge reading is obtained by reversing the cable connections to the bridge and locating the fault from the opposite direction. Both readings should locate the fault at the same place after making due allowance for equivalent conductor lengths.

A further refinement and greater accuracy may be obtained if the bridge readings are made from either end of the faulted cable. This method permits the elimination of the resistance of the return conductor in the calculations. Balance equations are obtained from either end and it is then a relatively simple matter to

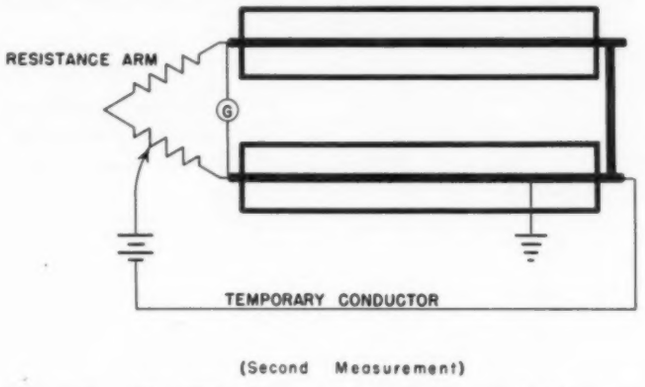


Figure 3 — The Fisher loop is a refinement of the Murray loop test.

manipulate the equations so as to eliminate the resistance of the return conductor. This simplifies the amount of calculation necessary to locate the fault and makes it possible to use any conveniently located return conductor.

b. Fisher Loop.

The Fisher loop test may be used to locate ground faults or short circuits. It is a further refinement on the Murray loop which eliminates the resistance of the return conductor and allows all measurements to be made from one end of the cable. The method requires two good conductors of any size or length. The first test is a straight Murray loop with the battery connected to ground. In the second test, the bridge connections remain the same, but the battery is connected directly to the far end of the loop via the third conductor. Suitable manipulation of the balance equations for the two conditions eliminates the resistance of the return wire.

c. Werren Overlap.

Some rather specialized Murray loop modifications permit measurement of fault locations when all conductors are grounded but continuous. The Werren overlap method requires the use of two identical bridges, one at either end of the cable. Alternate readings are taken as rapidly as possible with the far end battery disconnected and the far end loop short circuited. A number of readings should be obtained, averaged, and then inserted in a set of balance equations. This test can be used with ground resistances varying from a few ohms to megohms, but the fault resistance should be at least five times the copper resistance of the cable loop. The method fails when the resistance arms of the bridge are equal.

A slight modification of this method permits all the measurements to be made from one end. Both of these methods involve approximations which may easily negate their possible value when applied to conductors of low resistance. At their best they are capable of good results and at worst will determine an approximate location.

d. Inverted Murray Loop.

The regular Murray loop becomes increasingly insensitive as the fault resistance increases. Greater sensitivity can be obtained by interchanging the positions of the galvanometer and the battery in the bridge circuit, but the effects of local galvanic cells and stray currents are then introduced directly in the galvanometer circuit making balance to a false zero a necessity. Difficulties arise from stray currents which may be of sufficient magnitude to burn out the galvanometer, or from the likelihood of circulating excessive currents through the slide wire which will introduce errors or perhaps damage the bridge.

e. Jackknife Bridge.

A very useful modification of the Murray loop is the "jackknife bridge" which can be used for the direct location of grounded conductors. The method consists in laying a lightly insulated wire along the cable route to function as a slidewire and connecting either end to the faulted conductor. Ordinary bell wire is satisfactory for this purpose. Either an unfaulted conductor or a second temporary wire is again connected to either end of the faulted conductor with a galvanometer being inserted in this circuit. One side of the battery is connected to ground and contact is then made along the

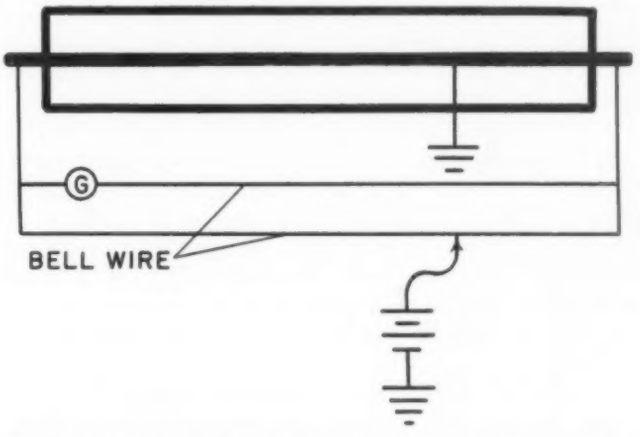


Figure 4 — The jacknife bridge, another modification of the Murray loop, can be used for direct location of grounded conductors.

slidewire with a jackknife or other sharp instrument. If a zero center galvanometer is used, the reading will be upscale on one side of the fault, downscale on the other, and will not deflect at the fault location when battery contact is made on the slidewire. The jackknife bridge requires little in the way of equipment and is useful if the cable run is short or the fault is known to lie in a particular section. The field application is actually a tracing scheme rather than a measurement scheme, but the method is included in this section as the limitations are the same as for the normal or the inverted Murray loop depending upon the relative positions of battery and galvanometer.

f. High Voltage Murray Loop.

Users of Murray loop schemes are generally satisfied with the results if the fault resistance can be reduced to a low value. Faults presenting a high resistance, as in joints where a fluid filling compound has been used, are difficult to locate due to the wide range of galvanometer insensitivity. This drawback has led to the development of a high voltage Murray loop bridge. The principle is the same as with the low voltage bridge, but a step-up transformer and rectifier tube are used to provide the requisite high voltage. The bridge is operated using an insulated slide wire and controls. A spark gap is placed across the galvanometer to protect it from burn out. The bridge is initially balanced with a current in the order of several mills, final balance is usually obtained at a higher current to obtain increased sensitivity. These bridges have been built to produce voltages up to fifty kilovolts with generally satisfactory results being obtained.

Failures on branched circuits may be located with the Murray loop if the following procedure is used. Make the first location with the main feeder looped through. If this test indicates that the fault is at or near a joint, suspect that the branch is faulty. Remove the loop on the main feeder and put it on the open end of the branch circuit. If the second location shows the failure to be in the joint, break it down. Otherwise proceed along the branch circuit to the fault location as determined by the bridge measurement.

The Murray loop should not be used on paralleled cables nor should it be used on cables where there is a probability of their being simultaneous faults. In either case the readings will be indeterminate.

The effectiveness of the Murray loop method is wholly dependent on the care exercised in setting up the bridge circuit and upon the exactness with which the measurements and calculations are made. As the conductor size increases in cross section, a small error in measurement will cause a very appreciable error in the location of the failure.

Capacitance measurements — Capacitance measurements are extremely useful for calculating the location of open circuits in cables where it is impossible to reduce the fault to a low resistance by a carbonizing procedure.

a. Alternating Current Capacitance Bridge.

An alternating current capacitance bridge can be used for making capacity measurements on open circuited conductors having fault resistances down to approximately two hundred ohms, at which point the cable impedance starts to become inductive in nature. The bridges usually consist of two variable resistance legs wound to minimize the effects of self inductance and capacitance. The third leg is composed of a variable resistor and condenser, while the remaining leg is constituted by the capacitance formed between the faulted conductor and the metallic sheath or shielding. The bridges work at a relatively low voltage and in either the power frequency or audio frequency range. The null detector may consist of a set of head phones or a visual indicator.

In operation, the bridge is adjusted until a balance is attained, at which point the capacitance and resistance of the bridge equals the capacitance and resistance of the faulty cable. The combination of variable resistor and condenser in the bridge is necessary as an open circuited conductor with a relatively low insulation resistance cannot be balanced against a loss-free condenser. The value of capacitance obtained for the faulty conductor is then compared with the value of capacitance obtained when testing a good conductor and the fault is located in proportion to cable length and the ratio of capacitances. If all terminals of the bridge are available, the bridge may be balanced by using a good conductor as the third leg of the bridge and the faulty conductor as the remaining leg.

Precautions to be observed include grounding all conductors not under test in order to eliminate errors originating from partial capacitances to other conductors. The far end of the open circuited conductor under test should also be grounded.

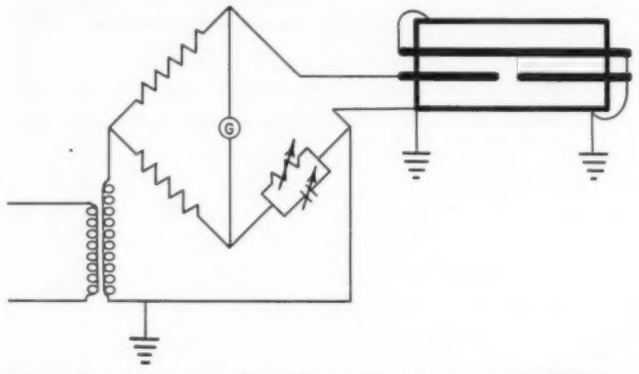


Figure 5 — In using the alternating-current capacitance bridge, the bridge is adjusted until the capacitance and resistance of the bridge equals those in the faulty cable.

A capacitance bridge is customarily shielded from the influence of electrostatic fields. Their influence may be further negated by using a reversing switch on the source voltage to the bridge and averaging the readings of capacitance secured in both cases.

If the connecting leads from the bridge to the conductor under test constitute an appreciable part of the capacitance reading, the capacitance of the leads alone should be determined and subtracted from the bridge reading.

Circuits consisting of cables of various sizes and constructions must be compensated for by determining an equivalent circuit length such as was done for conductors having different values of resistance per unit length. Capacitance varies only slightly with temperature, this variation being less than the change in conductor resistance, so this effect can be ignored with little concern over any loss in accuracy.

The effects of end leakage over the termination between conductor and sheath may be eliminated by interposing a guard ring on the insulated termination which will bypass this leakage current past the null detector.

Open circuit faults may be located on branch circuits using capacity measurements if it is known that the fault exists on the branch. This can be accomplished by calculating the equivalent length to the fault as determinated from the bridge measurements. From this distance subtract the equivalent length of all mains and branches excepting the faulted branch. The distance to the fault may then be determined as the remaining

equivalent length as measured from the beginning of the branch. If the fault is not known to exist in a particular branch, the method is indeterminate.

If there is no sound conductor with which to compare the capacitance of the faulty conductor, a satisfactory procedure is to measure the capacitance of the faulty conductor from both ends. If measurements cannot be made from both ends, resort may be made to calculating the capacitance of one conductor to ground for the circuit length, though this will not produce good results with belted type cables.

The audio frequency bridges are generally more suited for capacity measurements on short lengths of cable, while the power frequency bridges generally give better results on the longer cable circuits.

Application of the method is dependent upon a thorough knowledge of circuit construction and constants; the accessibility of far end terminations and removal of all apparatus from the circuit if the best accuracy is to be obtained; and an open circuited conductor with a fault resistance to ground of several hundred ohms or larger.

Though the alternating-current bridges produce the most accurate locations, mention might be made of two basic schemes for making capacitance measurements when the open circuit fault resistance is greater than a couple of megohms. All of the foregoing considerations applicable to capacitance measurements made with an alternating current bridge will apply to these methods, in addition to their being several other conditions necessary if successful results are to be secured.

b. Ballistic Galvanometer.

Capacitance measurements may be made using a ballistic galvanometer. The method consists in charging the conductor from a direct-current source, connected between the conductor and ground, and then discharging the conductor through the galvanometer. The deflection of the galvanometer is then proportional to the capacitance of the cable under test.

Since the capacitance of a cable is reasonably independent of voltage, a low direct-current voltage should be used to minimize errors due to insulation leakage. The capacity measurement is most frequently measured during the time of conductor discharge, rather than during the charging period, as this lessens the errors involved when a low insulation resistance is encountered.

The effects of non-linearity of the galvanometer movement may be overcome by using a universal shunt so that the galvanometer deflections are of nearly equal magnitude for all measurements of capacity. The readings must then be corrected for the value of the shunt multiplier in the usual manner.

If the galvanometer position is changed, it is advisable to check the galvanometer deflections against a standard condenser in order to determine whether the presence of extraneous electrostatic fields is influencing the readings.

This method fails to produce good results when there is a pronounced galvanic electromotive force developed at the fault or when stray currents are flowing, either of which condition is indicated by permanent galvanometer deflections. The method also fails on short cable lengths or when the insulation resistance is reduced to a low value.

c. A-C Charging Current.

In some cases the capacitance measurement may be easily made at power frequencies using a milliammeter to measure the charging current at constant values of voltage and frequency. As with the direct-current method, comparison is made between the faulted conductor and a good conductor, the charging currents being proportional to the distance to the fault.

Transit Time Measurements—The principle of applying short duration pulses to a faulted conductor and measuring the time of transit between the transmitted pulse and a pulse reflected from an irregularity is in the process of development at the present time. The scheme may be used to locate ground faults, short circuits, and open circuits. This method has been successfully applied to overhead transmission lines, but a great deal of additional work is necessary before this system can be adapted for use on power cables.

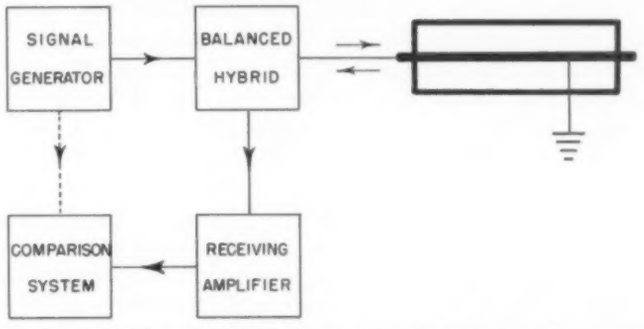


Figure 6 — Transit time measurements so far can be more successfully applied to overhead lines than to power cables.

Any discontinuity in a circuit will produce a reflection when subjected to a pulse unless the circuit is terminated in a resistance or impedance equal to the line surge impedance, in which case the termination absorbs all the power and there is no reflection. The different schemes transmit a pulse having special characteristics which are attenuated and distorted by the circuit being tested. The characteristics of the reflected pulse are then measured to obtain an indication of the fault location.

The pulse transmission method applies a steep wave front of voltage to the circuit and the time of transit between transmission and reception of the reflected wave is measured. This transit time may be measured by an electronic timer or it may be measured on a cathode ray oscilloscope that has a calibrated time base superimposed on the horizontal sweep circuit.

When a cathode ray oscilloscope is used, the fault location is obtained by comparing the oscilloscope trace of the faulty conductor with the trace obtained from a good conductor and noting any points of dissimilarity. The distance to the fault is then calculated using the distance markers generated by the timing circuit. An open circuit fault reflects a pulse of the same polarity as the transmitted pulse, while a short circuit fault reflects a pulse of the opposite polarity when viewed on the oscilloscope.

The frequency modulation method uses the instantaneous frequency difference between transmitted and

reflected signals to produce a beat frequency which is used as a measure of time delay and thus of the distance to the fault.

With both types it is necessary to match the impedance of the apparatus with the surge impedance of the cable in order to eliminate doubly reflected waves which would indicate a second fault at twice the distance.

The application of these methods to fault location on cables is limited for several reasons. The surge impedance of cables is on the order of fifty to sixty ohms while the fault resistance is frequently higher than the surge impedance so that the characteristic of the cable is not changed enough to obtain a satisfactory reflection; or if a reflection is obtained, the signal is very weak. The pulse reflected from cable systems does not have a sharply defined leading edge making ranging more difficult, and increasing the probability of error in computing distance to the fault. Each change in cable size or type may produce its own reflection making interpretation of the traces more difficult. When more than two or three taps are involved in the circuit the trace is rendered almost worthless.

A recent development in this field superimposes the test pulse on a high voltage obtained from a direct-current thyratron tracing set. The high voltage breaks down the fault resistance to a value lower than the surge impedance of the cable thereby producing a good reflection. The transit time is then converted to the approximate fault distance and the final location is determined in the field using tracing current methods. If the circuit has branches, there may be several field locations that will require investigation before the failure is located.

TRACING SCHEMES

Tracing schemes generally require free access to the cable along its entire route. However, faults can be located without the necessity of knowing circuit constants or of making calculations. Certain tracing schemes permit fault location while the circuit is energized and others may be used without disconnecting apparatus at the circuit terminations. These schemes may utilize the electromagnetic fields produced by the tracing current or the detection of vibrations produced by arc over at the fault location.

Electromagnetic field measurements—Most tracing current schemes are predicted on the existence of an electromagnetic field. Trouble is therefore encountered when the cable construction is such as to reduce or eliminate the strength of this field. Suppose, for example, a fault occurs on a single conductor lead covered cable installed in such a manner so that there is no way for the tracing current to return other than by the lead sheath. Under this condition, the electromagnetic field external to the sheath is for all intents practically neutralized and either no signal is detected or it is so weak as to be indistinguishable from noise picked up from external fields. This is the exceptional case though, as there are generally several paths by which the return current can flow so that a signal can be detected using the pick-up coil. It does serve to exemplify the conditions that may possibly be encountered.

Difficulty is also experienced with certain circuit configurations, as when a circuit is grounded only at the end remote from the test set. Then for a fault from conductor to ground, a pick-up coil will not detect any change in signal strength when passing over the fault.

Both of the foregoing fault conditions may be satisfactorily located if a low resistance shunt is used to bypass the sheath current around the pick-up coil. This procedure will strengthen the magnetic field if the shunt is made to pass directly over the coil, but some difficulty may be encountered in breaking away the cable fireproofing and securing intimate contact between the shunt and the lead sheathing. An alternative method is to provide parallel return paths either by stringing a wire for the length of the section and tying it to the sheath at both ends, or by tying the sheath in to adjacent grounds as water lines, fire hydrants, guy wires, etc. Where there are parallel return paths, signal strength may be increased by cutting a ring out of the sheath and thus interrupting the sheath current. The ring must be taped up immediately and rewiped as soon as feasible in order to prevent the entrance of moisture.

The neutralizing effect of conductor and sheath currents can be overcome in multiple conductor cable having an eccentric lay, by utilizing a flat coil that does not encircle the cable. The magnetic field set up by the current in the conductor is not exactly parallel with the field formed by the sheath current. Thus the component of the conductor field at right angles to the sheath essentially neutralizes the field created by the sheath current, leaving the component of the conductor field parallel to the skewed direction of the conductor as the field detected by the coil.

Between the test set and the fault location, there will be a noticeable increase in sound directly over the conductor carrying tracing current as the pick-up coil is slowly rotated around the periphery of multiple conductor cables. Beyond the fault there will be either no sound due to the absence of sheath current, or there will be a uniform sound as the coil is rotated due to equally distributed sheath current alone.

Signals may also be detected on other cables due to current returning on the parallel sheaths, in which case the sound will be of uniform strength around the conductor. Properly tagged and identified cables will eliminate the necessity for checking all of the cables in a manhole and will eliminate any confusion that might possibly arise from reading signals on the wrong cable.

The pick-up coil may be wound in two sections and connected in astatic formation. This construction eliminates interference from stray fields, but reduces the signal strength and completely eliminates the signal on single or twin conductor cable.

When the fault involves at least two conductors and ground, the tracing current should be applied either between two conductors or between one conductor and ground depending upon which method produces the stronger signal. When parallel return paths are lacking, a stronger field is usually obtained by connecting the transmitter between the two conductors. If the set is connected between two conductors, it is necessary to disconnect all apparatus to obviate incorrect signals which would otherwise occur. It is not always necessary to disconnect the apparatus in order to locate a ground

fault, but a far greater degree of skill and interpretation is required; with the ever present possibility of making an error such that the additional time may well be expended in clearing up the circuit. In any event, it is usually necessary to disconnect grounded neutrals where the neutral connection provides a metallic path parallel with the fault or where a parallel path may be formed by transformer action.

Cables that have a steel wire armor or are enclosed in iron conduit present additional difficulty in tracing as the high magnetic permeability of the covering further reduces the strength of the external magnetic field.

When using tracing current methods to locate a failure, it is best to proceed systematically. If the cable is short and easily accessible, the operator can start at the set and continue along the cable route until the fault is located. On long cables or routes where the cable is inaccessible, it is usually best to proceed by the halving method. Once the fault has been located, the operator should return to the location where the signal was last detected and recheck his determination to ensure that the set is still operating.

a. Woodpecker.

The woodpecker method may be used for locating low resistance grounds or short circuits. It is one of the earliest schemes developed and it utilizes a high frequency tracing current signal. The signal is generated using an induction coil, a vibrator, a slow speed interrupter, and a battery power supply. The output of the apparatus is connected across the fault and a search coil with telephone receiver detector is then moved along the cable route until the fault is located. The point of failure is made evident by the change in sound level that is heard on either side of the fault.

The high frequency current is particularly prone to produce misleading results on high resistance faults, for the charging current is then liable to equal or exceed the magnitude of tracing current such that there is no detectable difference in signal intensity on either side of the failure. Instead, a steady diminution of signal is experienced as the operator approaches the remote end of the circuit.

The woodpecker set has the advantage of simplicity in operation and of being readily portable. However, its output capacity is limited and it has no self-contained facilities for reducing the fault resistance.

b. Interrupted Alternating Current.

The interrupted alternating current tracing scheme (usually line frequency) may be used for locating shorts and grounds in much the same manner that the woodpecker is used. This method provides an advantage in that an induction regulator may be used in conjunction with a step-up transformer and a current limiting reactor, to produce voltages of sufficient magnitude to break down and carbonize a high resistance fault. An identifiable signal may be obtained by manually raising and lowering the induction regulator so that current is available for tracing even on failures that are not easily carbonized such as are often associated with submerged faults.

An ingenious method has been developed to eliminate the deleterious effects of sheath current when using this method. The detector consists of a split core current transformer and a polarized sheath drop device. The split core current transformer completely encircles the cable and produces a potential proportional to the vector sum of the conductor and sheath currents. The sheath drop device develops a potential in accordance with the amount of current flowing in the sheath. This potential is then added to the potential developed by the split core current transformer so that the detector indicates the conductor current at all times. The sheath drop device is far easier to apply in the field than is the relatively inefficient sheath shunt used with the woodpecker system to eliminate the effects of sheath current.

If a short circuit develops that does not involve ground, the set may be connected between phases with all apparatus removed, but a flat exploring coil must be used for tracing. Under this condition the split core transformer and sheath drop device would not give any indication of the presence of tracing current.

The disadvantage associated with the interrupted alternating-current method is the lack of portability, the required size and weight of the tracing current apparatus necessitated by the reactive component of current, the cost of the equipment and the high energy requirements. The set should be connected between one faulted phase and ground with all terminations and apparatus open circuited in order to reduce the charging current requirements to a minimum.

Some commercially produced models use an interrupted alternating-current tracer with a flat exploring coil which is useful for locating low resistance grounds and short circuits; particularly low resistance grounds on energized ungrounded systems. They are subject to the same limitations as the woodpecker scheme, i.e., difficulties are experienced from the effects of sheath current and also from the unavailability of a high output voltage for reducing the fault resistance.

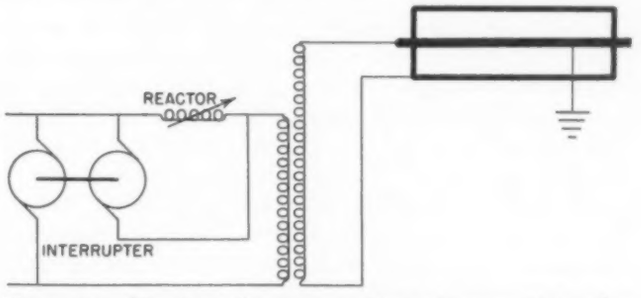


Figure 7 — The beat frequency alternate-current tracing scheme is used for locating shorts and grounds in very much the same manner as the woodpecker scheme.

c. Beat Frequency.

Several tracing current methods utilize a variable frequency source in conjunction with the line frequency to produce an identifiable beat which may be used for locating ground faults and short circuits. The beat frequency may be constant or an interrupter may be used to further identify the tone. These methods are readily adapted to locating grounds or ungrounded circuits while the circuits are energized and working, as the sets are easily paralleled by using transformers that have the required voltage ratio. Parallel operation may be used only if the fault resistance is sufficiently low that high voltage breakdown procedures are unnecessary.

Some of the commercial equipment utilizing this

method becomes quite elaborate, involving apparatus to analyze the fault condition, transformers having a selection of fixed output voltages, various sizes of reactor coils, and several types of exploring coils and associated amplifiers to take advantage of the differing electromagnetic field conditions encountered.

When the exploring coil is used with an amplifier it is possible to locate faults in buried cables. However, caution should be exercised in the event that signal reduction results from an abrupt increase in the depth of burial or that it results from the cable entering a magnetic enclosure. Difficulty may also be experienced on buried cable in differentiating between the tracing current on the cable and tracing current returning by a parallel path. Information pertaining to the cable route then proves its worth by eliminating the expense and delay encountered in making unnecessary excavations.

The equipment used with the beat frequency method is readily transported and has low energy input requirements, but again trouble may be encountered in carbonizing and locating high resistance faults and sheath currents may prove troublesome under certain conditions.

d. Interrupted Direct-Current.

The interrupted direct current tracing scheme furnishes an excellent method for locating ground faults and short circuits. The apparatus usually consists of a high voltage transformer, with a current limiting reactor and an induction regulator. Full wave rectification is secured by employing high voltage mercury vapor triodes in a bridge circuit. Recent tube developments have eliminated the necessity for the reactor and induction regulator by using a combination of thyratron and kenotron tubes in the bridge circuit to control the output voltage and current. A motor-operated switch reverses the phase of grid voltage on the thyratrons to control the duration of the direct-current outputs pulse. The detection unit consists of a galvanometer with an induction coil to indicate the presence of electromagnetic fields and a set of prods to indicate the presence of sheath currents. An isolating transformer is used with the prods to eliminate the effects of stray currents flowing along the cable sheath. The pick-up coil is used in the conventional manner to determine an approximate fault location. Final location is made by determining the direction of sheath current with the prods and the zero center galvanometer.

Location of a failure using the combination of pick-up coil and sheath prods provides a very satisfactory way of eliminating errors. The pick-up coil measures the vector sum of conductor and sheath current whenever it is applied between the test set and the fault location; whereas the use of the prods might not indicate tracing current when far removed from the fault location as the current may be returning by parallel paths other than the sheath. As the fault location is approached, the signal strength indicated by the pick-up coil decreases as the conductor and sheath currents become more nearly equal in magnitude and the electromagnetic fields cancel each other. If the prods are then used, high galvanometer deflections will be obtained as the sheath currents are at a maximum value adjacent to the fault. If the prods are always used in the same position relative to the source of tracing current, the galvanometer will deflect in opposite directions on either side of the fault thereby making for positive location. With some bonding conditions, the sheath current may all return on one side of the fault and the galvanometer would not show a deflection on the other side of the fault. However, this does not introduce any complications as long as the prods are always used for the final fault location. The prods may be used to localize a fault in buried non-metallic cable by the process of measuring potential gradient in the earth along the cable route. The prods of course will not indicate the presence of tracing current when the fault does not involve ground.

If excessively high voltage breakdown procedures

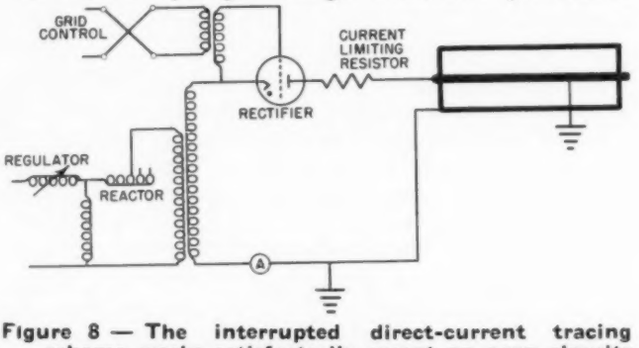


Figure 8 — The interrupted direct-current tracing scheme works satisfactorily except on open circuits or high resistance faults.

are not needed to reduce the fault resistance, a ground fault may be located without disconnecting transformers or other apparatus. The easiest way of accomplishing this is to apply the set between ground and all the other conductors tied together. By so doing, the likelihood of obtaining a misleading signal when using the pick-up coil is greatly reduced. Caution should be exercised in that the equipment connected to the circuit does not have such a low direct-current impedance as to be damaged during the application of tracing current. A short circuit not involving ground requires that all apparatus be removed from the circuit before locating the fault.

Since the output voltage is continuously variable, the set may be used for carbonizing a high resistance fault. This is accomplished by adjusting the grid excitation to provide continuous rectification. The output current must be carefully controlled to avoid damaging the tubes from excessive heat.

The use of a direct-current tracer eliminates the capacitive carryover on high resistance faults. Charging current requirements are reduced so that the size and weight of the apparatus may be held to a minimum.

Cables having an insulating binder interposed between the conductor shielding tape and the sheath may produce misleading results if the shielding tape is not bonded to the sheath at every joint. Otherwise a fault could occur between conductor and shielding tape and the tracing current might then flow along the shielding tape for some distance before appearing on the sheath.

The interrupted direct-current tracing set fails to produce satisfactory results only on open circuits or other high resistance faults that cannot be burned down sufficiently to permit tracing current to flow. A value of three to five amperes is usually adequate for tracing purposes.

High resistance faults that cannot be carbonized with the voltage available from a thyratron set can often be burned down using a high voltage kenotron set. The kenotron set is used to reduce the fault resistance to a value within the voltage range of the thyratron set and the two sets are then paralleled without interrupting the current. This procedure eliminates the exasperating experience of having a fault re-seal itself between the time of application of carbonizing procedures and the time of application of tracing current. The fault reduction is then continued using the thyratron set until the resistance is low enough to obtain a good tracing current signal. The thyratron set should be equipped with a protective gap to avoid damage in case the fault resistance suddenly increases while the two sets are paralleled.

The disadvantage associated with the high voltage interrupted direct-current tracer is the cost of the equipment and sometimes the energy requirements: though the input requirements are far less than for the interrupted alternating-current schemes.

e. Capacitance Impulse.

The capacitor impulse method may be used to locate ground faults and short circuits. In its simplest form a high voltage capacitor is charged through a step up transformer, current-limiting resistor, and a rectifying element. The capacitor is then discharged into the cable either when the applied voltage becomes great enough to jump a spark gap or when a motor operated gap is closed.

Application of the method is not dependent upon reducing the fault resistance to a value low enough to pass tracing current. It is only requisite that a high voltage is developed capable of arcing over the fault. The set should be connected between as few conductors as possible to reduce the capacitance of the circuit. If the fault resistance is low enough, it is not necessary to remove transformers or high impedance apparatus from the circuit.

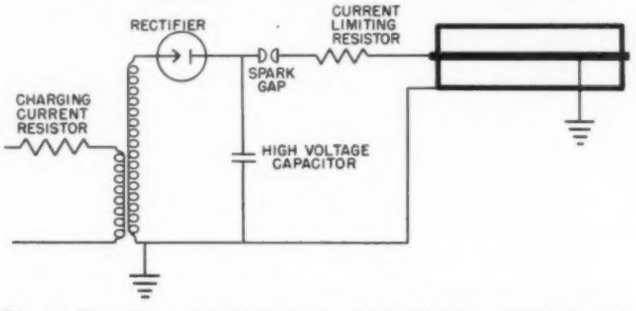


Figure 9 — The capacitance impulse scheme requires only that a high enough voltage be present to arc over the fault.

Little difficulty is experienced with carryover on high resistance faults as the wave shape of current on either side of the fault is such that a suitable electromagnetic field detector can differentiate between the two. A commercially available set has a detector that makes use of a delay network to identify the signals. Thus on the near side of a fault, the conductor current wave is a symmetric and the delay network retains the signal to bias a vacuum tube amplifier producing a visual signal. On the far side of the fault, the current is more nearly symmetrical and a defletion will not be obtained due to conductor current. However, a deflection may be obtained due to sheath current, but this will be of uniform strength around the cable periphery.

If the fault resistance is very high, the fault may not arc over on the first application of voltage and the cable will then be charged as a capacitor until arc over does occur. If a zero center detector is used and the pick-up coil is polarized relative to the test set, a negative reading will be obtained on the far side of the fault.

The advantage of the capacitor impulse method lies in the portability of the test set, in its low energy requirements, and in the fact that the sound of the arc-over may be readily heard near the fault and may be used alone or as verification of the fault location as determined with the pick-up coil.

Difficulty may be encountered with submerged faults or when a large number of transformers are connected, where the fault has a high breakdown strength and the cable charge is slowly dissipated during the off interval such that arc over does not occur and misleading signals will be obtained beyond the fault location due to charging current. Other difficulties arise when a large number of taps prior to the fault location reduces the peak value of voltage and where buried cables have a metallic covering which reduces the signal strength, necessitating the digging of test holes.

Vibration Measurement — A further refinement of the capacitor impulse method has been developed to accurately locate faults on buried cables of all kinds if the fault resistance is high enough to cause an arc over. The fault is approximately located using an induction coil. Then a piezoelectric crystal is used with an amplifier and an output meter to detect the mechanical vibrations produced when the fault arcs over. This method eliminates carryover of sound on metallic shielding and will locate faults on cables buried to a depth of ten feet or more although the sound cannot be detected until within several yards of the fault. A sound level meter makes a suitable detector as it contains all of the necessary components and is easily transported. The fault is located at the point of maximum sound.

SUMMARY

There are many other schemes that may be used for locating a cable failure. Some are very simple, as the spark testing methods, but are also very limited in their application under field conditions. Others, as harmonic analyzers, are more complicated but again are limited in their adaptability.

Under some conditions a savings in time can be realized by using a combination of methods as when a measurement scheme is used to determine an approximate location and then a tracing current scheme is used to make the final fault location.

It is thought that the schemes herein mentioned, cover those methods that have performed satisfactorily in the field. The ideal method for locating faults has yet to be devised and until that time it is advisable to have the cable system properly mapped and identified; to be familiar with the limitations of the various schemes; and to be prepared to apply a liberal amount of ability and ingenuity in order to locate a cable failure in as short a time as possible.

Western Engineers Face New Challenges

By L. S. DAHL
Vice President, Operations
Columbia-Geneva Steel Div.
United States Steel Corp.
San Francisco, Calif.

. . . . from a talk given at the AISE Western Section meeting in San Francisco, Calif., March 21, 22, and 23, 1955 . . . .

▲ THE steel industry, like most industries in the west, is quite youthful compared to the east and middle west, and we face many important problems attributable to the continuing rapid development of this area. The membership of the AISE already has contributed substantially toward easing the growing pains of this industry. The manner in which they have helped meet the problems of unrestrained growth in the immediate past is recognized as firm assurance that the organization can be counted upon to help meet the challenges ahead.

Perhaps we can best understand what is required of us if we look at the west as a whole and focus on some of our local problems. This district includes the 11 western states from Montana to New Mexico and Colorado to the Pacific Ocean. This is big country — it occupies 40 per cent of the land area within the United States. In distance, New York City is closer to St. Louis than Los Angeles is to Seattle. From Salt Lake City to San Francisco is farther than Pittsburgh to Birmingham.

The west has every kind of physical surrounding, resource and climate. There are green forests, wide deserts, snow-capped mountains, fertile valleys, rich minerals, cool deep lakes, rushing rivers, quiet bays and the vast Pacific Ocean.

Migration from other sections of the United States into these 11 western states is of a size that is surpassing anything known in history. We had 14,000,000 people in 1940. In another five years, our population is expected to be almost double that figure. Our growth from 1940 to 1950 was three times as fast as the growth in any other area of the country.

When Hendrik W. van Loon wrote his fascinating geography some 22 years ago, he predicted that California had only started upon its career as one of the most densely populated spots of the entire North American Continent. Today we are even more certain of his prediction. Knowledge of the growth in the western states is wide-spread among economists and business leaders throughout the country. Today they are well aware of this growth in population, income, and industrial activity, and those in the best position to analyze trends have, with increasing frequency, emphasized that these and many other area growths will continue at a rate considerably above the country as a whole.

Unquestionably, the impact of growth will be felt in the west for years to come, and new problems will beset us as this rapid and extensive trend continues into the future.

Often, you have heard it said that people make markets. As we view the years ahead, we cannot ignore the new opportunities that will abound here and the necessity of providing locally more and more of the products people need. It may be a long time before the west will be able to supply all of its steel requirements, but much progress has been made in that direction.

The production of ironmaking in this area made a modest start from 80 years ago, and the first open hearth began operation at Pueblo, Colo., in 1902. Population centers were widely dispersed in those early days, the vast expanses of the west held only 8 per cent of the nation's population, and steel requirements were light.

By 1940 the west's ingot capacity was slightly more than 2,000,000 tons and the operations of the former Columbia Steel Co. — now part of U. S. Steel's Columbia-Geneva Steel Division, for example, were relatively small scale, although it was the largest producer on the west coast. By 1950, steel capacity for this district had soared to more than 5,500,000 tons. Now it is well over the 7,000,000-ton mark.

Future capacity in the west is anyone's guess. We do recognize, however, that further expansion here is dependent on many factors, among the most important

of which is the assembly of both raw materials and diversified production economically in relation to marketing areas.

Since 1947, United States Steel has improved and modernized existing equipment, and added new facilities. An important share of this is here in U. S. Steel's western operations. The product lines of our mills here have been diversified since the end of World War II, and many changes and new additions have been carried out to adapt our facilities to the production of peacetime products.

Careful analysis has been made each step along the way to insure that the development of our production facilities in the west is best designed and carried out to fit in with both current and future steelmaking requirements of the area. The present high cost of steelmaking equipment has emphasized the importance of careful facilities planning. Facilities planning is of prime importance in our industry and receives a great measure of attention.

Our market research people have devoted much time and analysis to appraising, from a commercial point of view, all proposals for new facilities. I cannot overemphasize to you the importance we place upon the future market for each of our products in shaping our long range plans for expansion. While we realize that certain calculated risks are involved with the use of any forecast, we rely heavily upon the fact-finding services of our organization.

Today, United States Steel employs more than 20,000 men and women in its mills, mines, warehouses, and offices throughout the 11 western states.

The steady increase in numbers and importance of manufacturers of steel products in the west comes as no surprise. Steel-using industries cannot and have not ignored the fact that new opportunities await them here, based upon the two primary essentials of a manufacturing enterprise — materials and markets. In the short period since the beginning of World War II, both of these have substantially increased in availability. In that same period, manufacturing employment in the 11 western states increased 110 per cent.

The following statistics show an accurate picture of new opportunities for the west. About 2,500,000 tons of products employing steel in their manufacture still are being shipped into the western states each year. This includes 1,500,000 tons of motor vehicles and parts, and an additional 1,000,000 tons of machinery, agricultural equipment, household appliances, electrical equipment, and other products.

With an adequate and diversified supply of steel available, plus freight differentials and other savings, it is a reasonable assumption that more of these products could be made in the west at a satisfactory profit. A typical example is that of motor vehicle parts shipped for assembly and replacements. We import annually 1,000,000 tons of parts while we fabricate here only 100,000 tons of automotive parts for original equipment.

Thus we still lean heavily on the rest of the nation for many things. The west today accounts for only 9.9 per cent of the nation's value added by manufacture. With even greater gains in population anticipated, the opportunities for business and industry are obvious.

Although the west is rapidly moving up in steelmaking, we find ourselves still beset with quite a few problems that are of much less concern to our eastern cousins. The heavy concentration of steel plants in the east and middle west gives those areas certain advantages which we lack at present. For instance, many of the colleges and universities there have extensive curricula designed for the needs of iron and steel engineers. More young men are exposed to "shop talk" of our industry in the home and become familiar with many facets as they grow up. Logically, a large percentage of these men conclude their formal training with a steel industry career as their objective.

In the west, there are now four steel plants with more than 3,500 employees each. Of these, only three are fully integrated, with coke ovens and blast furnaces. Two of these plants were not operating prior to 1941. In western schools, curricula has never been designed for the steel industry. No reserve pool of manpower with steel works skills, much less steel engineering skills, has ever existed here.

To help the western steel industry to better meet the future needs of our surging population, it is essential that the public be well informed about the industry and it is equally important that our schools provide the necessary educational background for future iron and steel engineers.

Physical distance from the concentration of steel growths and development, plus his heritage, have made the steel engineer in the west both creative and self reliant. Most steel suppliers and equipment manufacturers have concentrated their efforts and operations within the boundaries of the industrial east. In the west we have been forced to improvise much of the time as a result of freight problems and delivery times. Too often the manufacturer has been unable to provide the technical help we need in a given situation merely because his representative failed to develop an authoritative knowledge about the product line he represented.

The small and distant market may be a natural for part-time factory representatives and catalogue salesmen, but the west is no longer that kind of market. Each man representing his organization should be expected to know his goods, and if the growing western steel industry is to be served effectively, vendors' local staffs must have well-trained men who can and will be of service on technical problems. Sending a man east for a few months' training will no longer suffice. We now look to resident representatives who are qualified sales engineers, authorities on their products and equipment.

Our western market is highly diversified and is becoming more so through the increasingly large number of small manufacturers of products made from steel. The characteristics of this market affect in many ways our operating personnel as well as the engineer. The small manufacturer may order carload lots, but each carload often contains many different products and sizes. To the steel operator, this means handling small order quantities and difficult scheduling problems on the mill. To the engineer, it presents the problem of developing a variety of equipment to produce a great variety of product.

Existing steel plants in the west now produce a wide variety of products. The design of facilities to meet these new requirements is a real challenge to the steel engineer. He must not only be skilled, but must also be

ingenious in the designing and layout of plant and facilities. He is responsible for the development of facilities that will afford the greatest possible versatility, in order that the operators can secure the fullest possible loadings and the owners of the business can obtain the maximum from their investment. The attainment of multiple product loading on single installations presents a genuine problem for the steel engineer whose plant serves a market for widely diversified products in a widely scattered market area.

Our swelling population, combined with industrialization, has multiplied the problems of providing the necessary services and protection of the people in expanding communities. Public officials are alert in the direction of proper legislation that takes into consideration the interests of all branches of our society including generally the common problems of industry. However, many of them are not fully advised of industry's needs. It is necessary, therefore, that the engineer as well as other members of management recognize the obligations of industry and be capable of assisting in the development of local ordinances for protection of the physical as well as the business health of the community with reference to proper health measures, fire districts, air pollution and water contamination controls, and anticipate the needs for common betterment.

Our state governments are extremely conscious of their natural resources and have legislated strong protective measures which must be closely observed. Plant effluent into navigable and fishing waters, for example, must be sufficiently free of contaminants to perpetuate the marine life.

Procurement and protection of water are problems faced by the steel engineer. The development of low-cost re-circulating water systems in the mills is typical of the ingenuity engineers have shown to avoid unnecessary waste of this important natural resource which has become increasingly precious in many areas.

Urban air pollution is a topic of increasing importance to the iron and steel engineer. He must be constantly aware of and actively engage in the development of preventive measures against any contamination. Engineers in United States Steel were among the first to recognize the problems and to initiate programs for the control of air pollutants. Torrance Works of Columbia-Geneva Division, in the Los Angeles area, in 1951 was the first steel plant in the nation to install electrostatic precipitators to remove particulate matter from each of its four open hearth furnaces. Industrialists, scientists, and government officials from the United States and many foreign countries have visited Torrance since then to study this trail-blazing accomplishment against contamination of the atmosphere.

A major need for common betterment of our western society is the requirement that we supply enough and as many kinds of steel as our swelling population requires to provide industrial employment so necessary to a balanced healthy economy. New highways must be constructed, additional bridges are needed, more factories have to go up, and utility networks need to be greatly expanded in the years ahead. Not the least of our needs is the new housing which will be required for the thousands of new families that are pouring into the western states.

Just how are we going to meet such enormous demands upon the steel industry in the west? The trend lies in the direction of still greater diversification and increased steel capacity in the west, and in the redesign of existing facilities to produce more and better products with what we already have. The challenge is one for competent engineers and management. The future is before us. I am confident the engineers of the AISE recognize the big job ahead and that it will be done in a manner befitting the reputation of your profession.

1955 AISE

ANNUAL CONVENTION

SEPTEMBER 26, 27, 28, 29

HOTEL SHERMAN **CHICAGO, ILL.**

PLATE MILL DESIGN AND ROLLING PRACTICE

. . . . plate mill consists of a 24 x 36 x 116-in., 3-high rougher and a 36 x 54 x 130-in., 4-high finishing mill . . . . slabs are kept in process in both mills simultaneously . . . . some plates can be finished on the 3-high mill and the combination gives excellent operating flexibility . . . .

By ELMER LYNCH

Superintendent Plate Mills and Tank Head Dept.

Sheffield Steel Corp.

Houston, Texas

▲ SHEFFIELD Steel Corp. was organized in 1925 from the old Kansas City Bolt and Nut Co. At present, in addition to the greatly expanded plant at Kansas City, there is a plant in Tulsa, Okla., rolling reinforcing bar exclusively, and the fully integrated plant at Houston with which this paper deals. In 1930 Sheffield became a wholly owned subsidiary of the Armco Steel Corp.

In 1940 construction of the Houston plant began on a 600-acre tract adjoining the ship channel where barge loading and receiving docks are located on company property. Products for export are moved approximately three miles by railroad to docks where ocean going vessels are loaded. In 1942, operation of this plant started with a capacity of approximately 35,000 tons of ingots a month. Building and expansion have continued until now the capacity has more than doubled.

The Houston plant now has:

a. Sixty-two coke ovens.
b. One 900-ton blast furnace.
c. Eight 160-ton open hearths.
d. One 100-ton electric furnace.
e. One 36-in. two-high reversing blooming mill.
f. One 2-stand, two-high, 26-in. billet mill.
g. One 8-stand, two-high, 19-in. continuous billet mill.

The three mills just mentioned may operate as a continuous unit, rolling a 23 × 25-in. ingot to 2 × 2-in. billets.

h. One structural mill consisting of two stands, 26-in., three-high; and three stands, 24-in., three-high.
i. One merchant bar mill consisting of one stand, 18-in., three-high roughing; five stands 14-in., three-high finishing; seven stands, 12-in., two-high finishing.
j. One 17-stand, two-high, semi-continuous rod and bar mill.
k. A wire mill producing a wide range of nails and wire products.
l. Two plate mills known as No. 1 and No. 2 mills.
m. The company also owns iron ore mines in East Texas.

Plate production started in 1942 on a three-high mill which will be referred to as No. 1. In 1943 another three-high mill was brought to the Houston plant from Youngstown on lease by the DPC. After the war, this mill was returned to Youngstown. In 1948 A. O. Smith Co. of Milwaukee and Sheffield formed a company known as the A. O. Smith Co. of Texas for producing pipe. The project called for more and larger plates, so the three-high, four-high or No. 2 mill was built by Sheffield.

The No. 1 mill, built in 1942, is a conventional three-high, 22 × 34 × 112-in. mill with two slab heating furnaces and an open annealing furnace followed by the leveller. The shears and all auxiliary equipment are the same as usually found in a single-stand, three-high mill. On the opposite side of the three-high drive is a three-high 22 × 32 × 84-in., mill with a hand operated screwdown, a continuous pack heating furnace, and tilting tables. This mill is used for rolling sheets.

No. 1 mill has not operated for some time since at present the more efficient No. 2 mill can roll all the steel

TABLE I

Ingot Size and Weight

Size, in.	Height, in.		Minimum weight	Maximum weight
	Minimum	Maximum		
18 x 41	52	62	9,100	10,800
23 x 25	79	85	11,500	12,300
22 x 45	73	78	16,000	17,200
26 x 45	73	82	19,000	21,400
Hot Top				
19 x 40	4-in. Block	8-in. Block	7,700	8,500
27 x 27	4-in. Block	9-in. Block	9,700	10,700
23 x 45	4-in. Block	9-in. Block	10,900	12,300

TABLE II

Slab Sizes

24 to 40 in. wide	1,280
68 to 100 in. long	to
$2\frac{3}{4}$ to $11\frac{1}{2}$ in. thick	15,040 lb

Limited to 40-in. slab width by blooming mill lift.

that can be allocated to plate production. Therefore, the details of plate mill practice that follows apply to the No. 2 mill.

In July of 1950, the A. O. Smith Co. of Texas began producing 16 to 30-in. pipe from plates rolled by Sheffield's newly built three-high four-high mill. This plate mill and the pipe mill are so closely coordinated that, if necessary, plates rolled today can be shipped as pipe tomorrow.

The No. 2 mill is located in a building adjacent and parallel to the blooming mill, with the bloomer rolling east and the plate mill west. This main building is

Figure 1 — Two slab heating furnaces are used on the plate mill. Shown here are slabs being charged into No. 1 furnace.

Figure 2 — The 3-high rougher is driven by a 4000-hp, wound-rotor, induction motor through a reduction unit with a 60-ton flywheel.

96 × 1450 ft and houses the discharge end of both slab furnaces, the two-high, scale breaker, the three-high rougher, the four-high finishing mill, the roll grinder, the roll storage and build-up area, and all shears.

Tables I and II show ingot sizes and slab sizes.

All plates at Sheffield are rolled from slabs produced in the blooming mill. Before charging in the furnace every slab goes over the scarfing docks, has both sides inspected and all defects removed by hand scarfing. The management feels that this pays big dividends in good surface on the finished product.

Slabs are scarfed and stored in three adjacent bays. The north bay is served by either of two overhead cranes which move lifts of slabs to the scarfing area and also load magazine pilers at the charging end of No. 1 slab furnace. Inspection of each side and scarfing are handled in this bay by a five-ton, single-hoist, gantry type crane which uses a magnet to handle the slabs. This crane can also place slabs on the charging line of the No. 1 slab furnace.

The middle bay is served by a ten-ton, single-hoist, overhead crane which uses chains for lifts and a magnet for individual slabs. Also serving this bay are two five-ton, wall type cranes, with magnets to handle the slabs for inspection and scarfing.

The south bay is served by a ten-ton, single-hoist, overhead crane with chains for lifts and a magnet for individual slabs. This crane also handles the charging of No. 2 slab furnace.

Slabs are heated in two-double row, end discharge furnaces, each 18 × 63 ft, and rated at 40 tons per hr, with the usual water cooled skid pipes and a flat solid hearth at the discharge end. Both furnaces are automatically controlled and are triple-fired with six burners in each zone. In actual operation, the furnaces get more than 40 tons per hr but the mill could definitely use more heating capacity. When ready for rolling, the slabs pass through the two-high descaling stand having fluted steel rolls 32 × 18 in. The screws are electrically operated and have a dial indicator. The mill is driven

by a 1500-hp wound-rotor, induction motor through a reduction unit with two flywheels and pinions, delivering a mill speed of 30 rpm.

The three-high rougher, 60 ft from the scale breaker, is a 24 × 36 × 116-in. mill driven by a 4000-hp wound rotor induction motor of 6600 v, 357 rpm, driving through a reduction unit consisting of a 60-ton flywheel and a pinion stand, delivering a mill speed of 48.5 rpm. The screws are 12-in. diam, 1¼-in. pitch, operated by two 150-hp motors with a screw speed of 36.5 in. per min, a mill opening of 14 in. The tilt tables are disc type, 29 ft-3 in. long with discs 17 in. diam. Each is driven by two 50-hp motors with a table speed of 405 fpm. The tilting motion of each table is provided by a 100-hp motor through a 21 to 1 reduction. The angle of the tilt is fairly well divided between up and down positions.

All auxiliaries on the three-high mill operate from a constant potential source. The 250-v, d-c power for the mill auxiliaries and cranes is supplied by a 1500-kw motor-generator set.

When No. 2 mill was being planned it was decided that adjustable side guards must be used on the three-high tilt tables. They have proved to be a tremendous help in keeping the slab in the center of the mill, entering square, and speeding up rolling. The guards have a 20-in. minimum opening, 116-in. maximum, and are 10 ft-1 in. long. Each is driven by a 15 hp motor. All necks on the two-high scale breaker and the three-high rougher operate on fabric bearings.

With the advent of the four-high mill, either reversing or continuous, the rolling of flat products was revolutionized. The four-high mill is located 185 ft from the three-high mill, and is a 36 × 54 × 130-in. reversing mill with a twin-motor drive. Each spindle is driven by a 3500-hp motor rated at 35-80 rpm. Power is supplied by an 80-ton flywheel motor-generator set. The driving motor is 6000-hp, 6600-v wound rotor motor rated 357 rpm. The two generators are rated 3000 kw, 700 v d-c. The back up-rolls have tapered necks operating in precision oil-flooded journal bearings. The necks on grain type iron work rolls operate on roller bearings. Screws are operated by two 75-hp motors with forced ventilation. They are 20-in. diam with 1-in. pitch, operating at a speed of 12.66 in. per min. The maximum mill opening is 15 in.

Figure 3 — The 130-in., 4-high mill has a twin motor drive with each spindle driven by a 3500-hp motor.

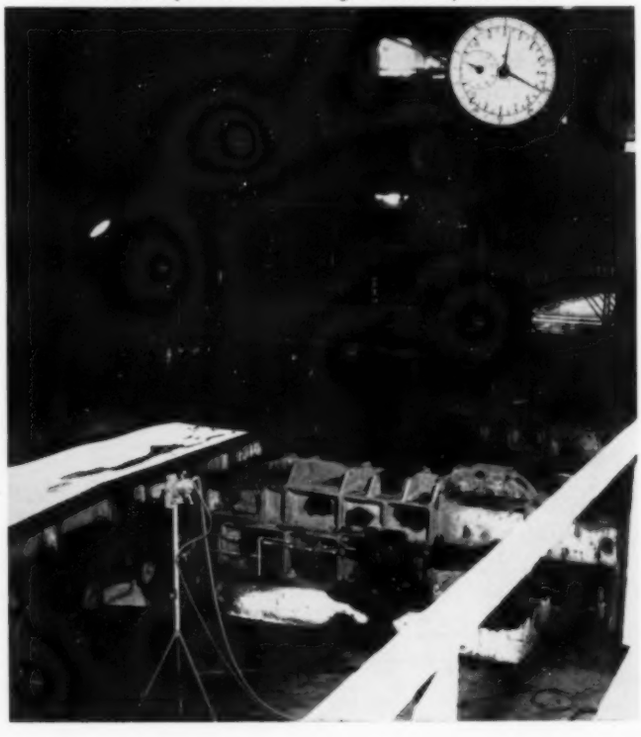


Figure 4 — Plate length is laid out on the inspection table.

The front mill table is 66 ft long with 23 rolls 130 in. long and 16 in. diam. The back table is 48 ft long with 17 rolls. The tables are driven by two 100-hp motors that operate from variable voltage and have forced ventilation. Table speeds are 350 to 700 fpm and are speed matched with the mill. The front side guard is 22 ft long, the back guard 17 ft long. Both have openings 21 in. minimum, 11 ft-5 in. maximum, and a speed of 6.5 fpm. The movement of the guards automatically follows the direction of the mill. There is an electric and hydraulic slab turner 50 ft from the four-high mill, also a centrally located descaling pump system supplying 1200 psi pressure to headers at the descaler, three-high, and four-high mills.

An electric eye on the front of the four-high mill records the temperature of the piece coming in from the three-high, and also that after each successive pass. These temperatures are shown on a chart in full view of the four-high operator and are of great value to him in adjusting the screw to get the proper thickness in the finished plate, or in giving additional passes to a cold piece.

The width limit of 40 in. on slabs does not permit a specific ratio between the slab thickness and that of the finished plate. However, when the finished plate is to be over one half in. thick, a ratio of approximately

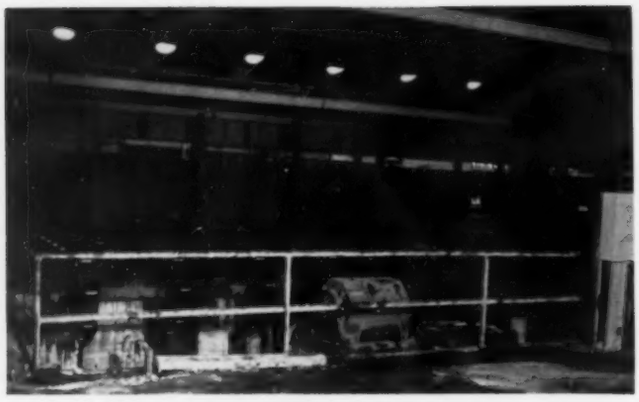


Figure 5 — After inspection, the plates are turned over.

three to one is maintained between the thickness of the slab as it leaves the three-high and the finished plate. When the thickness is to be under ½ in. the ratio is approximately four to one.

An effort is made to keep a slab in process in the three-high and in the four-high simultaneously. Should the four-high be delayed, a finished plate is made on the three-high. Should the trouble be at the three-high, the piece is sent on to the four-high above normal thickness. A slab put through the descaler only is returned to the slab yard for re-charging.

It is needless to say that the sturdy four-high will finish a cold plate that could not be attempted on the three-high. Better tonnage, a more uniform cross section, and higher recovery are definitely obtainable on the four-high mill. The three-high makes a satisfactory rougher. The two together make an ideal flexible plate producing unit.

The middle rolls on the three-high are replaced with rolls having additional crown to keep a uniform cross section on the pieces going to the four-high. Work rolls on the four-high are changed after four or five turns depending on the width and gage of the plates scheduled. There has been no trouble with spalled rolls and no conclusions have been reached as to what would be an excessive or dangerous crown on four-high.

Finished plates are carried on a crossover conveyor to a narrow bay parallel to the main building. This

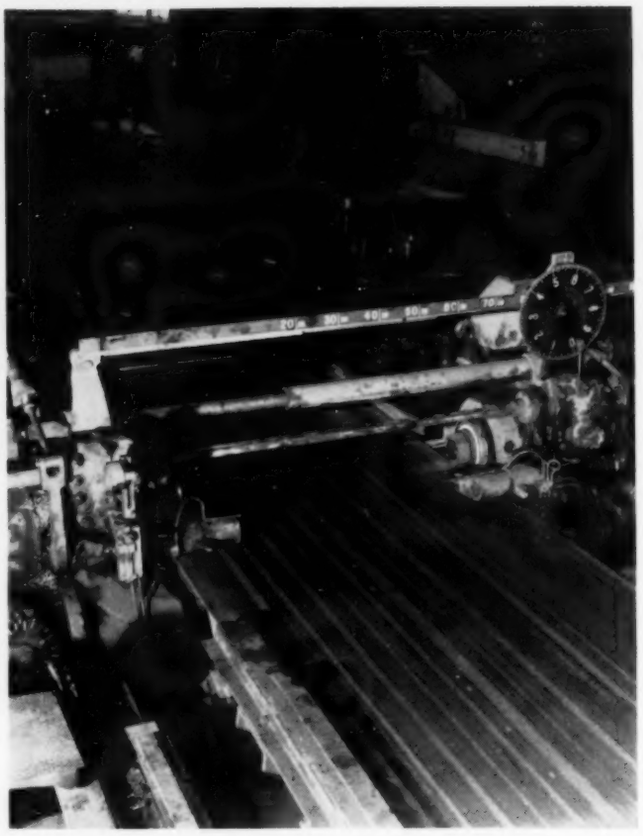


Figure 6 — Minimum scrap on rotary side trimming shears is about 1½ in.

building is known as the intermediate building. From here they enter an open annealing furnace. This furnace is 64 ft × 11 ft-4 in. with 33 alloy dry shafts or rolls 8½ in. diam. The rolls are driven by a 25-hp variable speed motor. The furnace is also reversing with speeds of 6.2 to 310 fpm either way. Temperatures up to 1750 F are automatically controlled.

These factors, with the varying time in the furnace, remove rolling strains and produce a more workable plate for fabrication, and a much flatter plate, particularly on wide, light gage products. Plates that might not meet flatness specifications or are bent in any way

TABLE III

Sizes of Plates Produced

Houston Plant

	Thickness, in.										
Widths, in.	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
	Maximum lengths — in.										
60	624	624	624	624	624	624	624	624	600	528	468
72	624	624	624	624	624	624	624	564	504	432	396
84	624	624	624	624	624	624	564	492	420	372	336
96	624	624	624	624	624	600	504	420	372	324	300
108			624	624	624	528	432	372	324	288	264

Length limited by width of crossover conveyor.

are reannealed and levelled again. Plates for the tank head department or customers who have severe fabricating conditions are given special attention in annealing. All furnaces are gas fired.

Following the annealing, the plates are levelled on a 9-roll leveller with rolls 12⅛ in. diam and driven by a 200-hp motor. From here they move on the first of three sections of roller chain type conveyors to an inspection table where the plate length is laid out. The other two sections move them to the turn over, then to the shear approach table. At this point the plates are reversing their direction and moving back into the main building. They have now travelled 1132 ft from the center line of the four-high mill.

Plates up to ¾ in. are end trimmed in the first shears to give a square entry to the rotary side trimming shears. The rotary shears have 15 in. top knives, 60 in. bottom knives, with 18 in. minimum, 116 in. maximum width opening, and a speed of 78 to 234 fpm. The shears are driven by a 200-hp motor; the scrap choppers by a 100-hp motor.

Scrap from the rotary shears moves on a chain conveyor to the intermediate building where it is loaded in cars. This building is served by a 10-ton single hoist crane with a magnet attachment.

The final end cut shears are equipped with an electrically operated length gage. Plates over ¾ in. thick are dummied through this set-up to a heavy duty side and end trimming squaring shears.

This set-up deviates from the usual plate shearing practice in that the sides are trimmed first, the ends, last. In this way the only laying out is the parallel width lines. The end cut shears have a graduated straight edge on the front and a squaring straight edge on the back. This speeds up the shearing since the end cuts are automatically square with the shear line, the lengths are good, and the plates are square.

Table III will show finished rolling sizes.

The main building is served by a 100-ton main hoist crane with a ten-ton auxiliary hoist, a twenty-ton, single hoist, double block crane, and a fifteen-ton, single hoist, double block crane. All are equipped with magnet reels.

There is a loading track in the main building that will hold twelve average cars. Most of the plate handling is done by magnet. South of the main building is an additional shipping building 96 × 525 ft in which are located spare shears, scales, and track able to handle eight average cars. Truck loading is also handled in this building. Plates are moved from one building to the other on a 100-ton electrically operated crossover flat car.

The mill has a complete communications system with units at all operating stations from the slab yard to the scales, and also in the mill office.

Figure 7 — Final end cut shears are equipped with an electrically operated length gage.

DISCUSSION

PRESENTED BY

ROBERT C. McMICHAEL, Supervisor 140 - 206-in. Mill, Lukens Steel Co., Coatesville, Pa.

WILLIAM E. BOGER, General Superintendent, Alan Wood Steel Co., Conshohocken, Pa.

A. N. RENZ, Plate Mill Superintendent, Wickwire Spencer Steel Div., The Colorado Fuel and Iron Corp., Claymont, Del.

MARK R. PITT, Superintendent of Rolling Mills, Broken Hill Proprietory Co., Newcastle, N.S.W., Australia

ELMER LYNCH, Superintendent Plate Mills and Tank Head Dept., Sheffield Steel Corp., Houston, Texas

Robert C. McMichael: Apparently a lot of effort has been put forth in the development of the mill layout, design of equipment and mill practice to assure the maximum production of good quality plates. Although this mill is not identical with Lukens 112 - 120-in. mill combination, it does have a lot in common with it. Our practice involves the direct rolling of ingots to plates, whereas the practice described involves the rolling of slabs to plates. I would like to ask a few questions:

1. Is the electric eye used in conjunction with an automatic pre-set screwdown mechanism?
2. Does the use of the descaling system influence the effectiveness of the electric eye?
3. Are working rolls of identical size used in the four-high finishing mill?
4. It was mentioned that composition bearings are in use on the three-high rougher. What changes in mill design were necessary to assure satisfactory performance of these bearings?
5. How does the quality of the occasional plate finished on the three-high rougher compare with those coming off the four-high stand?
6. How frequently are the top and bottom rolls changed in the three-high stand?
7. How frequently are the middle rolls in the three-high stand changed?
8. How often are the backing rolls changed in the four-high stand?

The similarity of mill conditions has made this paper extremely interesting and thought-provoking.

William E. Boger: What is done with the scale, if any, that is raised in the annealing furnaces? Are there any problems in heads or with head people from such secondary scale?

On the pusher type furnace I noticed on the slab sizes

that he went down to 2¾ in. and I am wondering what problems they might have with the telescoping of the shuffling up of the slab in the furnace.

I would like also to ask Mr. Lynch if he would care to elaborate a little bit on the minimum scrap sizes that he can handle on his rotary side trimmer. I would also like to have him elaborate a little bit on the position of the high rolling sprays and also on the passes they are using.

Also, is the head end of the plate cropped before entering into the side roller?

A. N. Renz: There are several things I would like to ask:

1. Is there an allowance or provision made for any anticipated amount of scrap?

2. Does the type of work that you have scheduled on the mill have any bearing on the amount of crown in the work rolls, or is the crown an established crown on your four-high mills?

3. What is the principal quality of the product produced on your mill? By this I mean; is it wholly for pipe skelp, or, what percentage is for pipe skelp and other type of quality production?

4. What is your expected yield factor?

Mark R. Pitt: We in Australia have been operating three-high pipe and recently have commenced to operate a four-high mill — starting in February, 1954. As a result we are more or less feeling our way and therefore have followed the very fine papers with a good deal of interest.

Would you give us a brief account of the amount of crown which is found necessary to use in your rolls, starting with the new back-up rolls until they are due for changing?

Secondly, I should like to ask if the lengths shown on the table are maximum lengths? Is the four-high mill equipped with attached edgers. If so, what are the thinnest plates to be produced as universal plates?

Elmer Lynch: Answering Mr. McMichael as to whether the electric eye is used in conjunction with the automatic pre-set screwdown, we do not have an automatic pre-set screwdown on our mill, so the answer would be no.

Next was asked does the descaling system influence the effectiveness of the electric eye? The film of water on the plates naturally will affect the electric eye somewhat, but we do not find it doing any particular harm on accomplishing what we want. The charts will show a stop momentarily, and then move on to the proper temperature, so it really does not have much effect on it.

We try to keep not more than 0.003 in. difference in work roll diameters. If there is any difference, the larger roll is used on top.

In connection with the composition bearings, our No. 1 mill and the three-high rougher in No. 2 mill came equipped for the use of such bearings. Chucks and bearings were fitted into the scale breaker with no change in housing design. Most of the change is in the chucks and we believe they could be fitted to most any three-high mill.

The quality of the occasional plate finished on the three-high depends on what we are working. Naturally, we have a little more crown or center, but the surface is as good as from the four-high. We seldom work light gage plates on the three-high stand, preferring to finish at thicknesses of ¼ to ½ in. thus giving a good salable plate instead of a cobble.

The middle rolls are changed on the three-high every week, and the top and bottom rolls every four weeks. This makes four middle rolls to each cycle of big rolls. Each middle roll has additional crown, the first roll starting with 0.076 in. on diameter.

The back-up rolls on the four-high are changed every three weeks. Nine or ten sets of work rolls will be used during that period.

The secondary scale in the annealing furnace is nil. Perhaps you get some if there is a delay in getting one through and out of the way, but you have to keep the plate in furnace an unusually long time. We do not raise scale or have secondary scale after annealing.

There is very little trouble with thinner slabs buckling in furnace, never on line skids, but the hearth must be kept in good shape.

The minimum scrap from the rotary shears is an inch and a half. If we get below that, we get some twisting due probably to the rotaries themselves, but you run into trouble on the scrap choppers when you get below an inch and a half of side scrap on the rotary.

There is a top and bottom descaling header on the exit side of the descaler, also on exit side of the three-high. The four-high has headers on the entry side.

We always square up the ends on the first end-cut shears for square entry into rotary.

We do not allow any particular overweight in the slab to take care of scarfing. We have not found that has affected us. We will occasionally come up with a bad heat or ingot which for some reason takes a larger amount of scarfing, and we may have trouble getting that into the finished plate.

The next question was "does the type of work scheduled on the mill have anything to do with the amount of crown in the work rolls, or is the crown an established crown"? The crown is an established crown, but we may at times change work rolls on the four-high after three turns. I mentioned four or five turns in the paper, but if finished sizes are such that the rolls should be changed in three turns, we do that, starting out with one flat set in the four-high mill.

On quality, I would say we probably roll sixty-five per cent of our product for pipe skelp. Our other products are all types of plate, A-7, A-212, some aircraft quality, also some alloys.

Our yield will run around 81¾ to 82 per cent.

On the question of crown, we start with one flat set in the work rolls on the four-high and then go to two sets of 0.003 in. crown and then to three sets of 0.005 in. of crown, and then to three sets of 0.008 in. crown. The crown is on diameter.

The chart showed 624 in. long as maximum length, however, we have rolled up to 665 in. long, and that takes every inch of the crossover conveyor to get plates transferred. I do not think there would be any trouble rolling plate 800 to 900 in. long on the mill.

We do not have an edger in connection with the four-high. We do have one between the three-high and four-high stands that is used at times to eliminate over-roll on thick slabs.

No universal plate is rolled on our mill.

By R. G. BEADLE, Steel Mill Engineering, General Electric Co., Schenectady, N. Y.

Characteristics of Tandem Mill Drives

. . . . developments in regulating systems for tandem mills have sometimes been so rapid that one selected for a mill in the design stage may be superseded before the mill is actually built . . . . present opinion is divided primarily between a system using a magnetic amplifier with a one generator field in a fairly complex circuit or the use of a combination of magnetic and rotating amplifiers in a simpler circuit . . . .

▲ THE development of tandem cold strip mills has been one of the most persistent and fast moving in the industry. As operating experience has increased over the years, these mills have made amazing progress in delivery speed, horsepower, and width, while at the same time producing better and more accurate steel. Part of this progress has been due to the ever improving electrical equipment.

The subject of this paper concerns primarily the regulating systems for such tandem mills. A brief description is given of the electric drive equipment which have powered these mills through their development as well as some description of the associated regulating systems. However, particular emphasis is given to the most recent regulating systems so that they may be evaluated to determine the present status of the art of tandem mill control systems.

ELECTRIC EQUIPMENT THROUGH THE YEARS

The first tandem cold strip mills which can be considered as production mills appeared around 1920 and usually consisted of four stands. These mills were arranged for considerable flexibility since all four stands could be operated as a group in tandem or the stands could be operated in units of 1, 2, 3 or 4 stands. These stands were usually powered by adjustable speed d-c motors connected to a constant voltage bus where acceleration and deceleration could be controlled first by steps of armature resistance and then by steps of field resistance. These motors generally had a speed range of field weakening of 2 to 1 and varied in horsepower from about 50 to 300 hp, but with any given tandem mill usually having motors of identical rating on each stand. Since such a scheme of control made accurate speed correspondence during acceleration or deceleration very difficult, the mill was usually operated with loops between stands. It is interesting to note that the characteristics of such adjustable speed motors were not well suited to the rolling of strip. As a mill is accelerated it requires a nearly constant torque, but this drive system did not inherently provide this characteristic.

Realizing that a drive which was capable of constant torque during acceleration or deceleration was better suited, the adjustable voltage system of control was instituted around 1930. In this system, all motors on the tandem mill were connected to a common adjustable voltage bus where acceleration or deceleration was accomplished by varying the voltage of this bus. During these speed changes, the motor field remained constant and therefore approximate speed matching was obtained. With this type of drive tandem mills emerged from their infant stage. This basic adjustable voltage system was certainly an improvement over the constant voltage adjustable speed motors used at the beginning, but there were still many problems encountered. Most of these problems had to do with low speed operation such as at threading, and during an acceleration. Many steps were taken to try to devise regulating systems which would give a more desirable characteristic over the whole speed range; some of these steps were constant current regulators on each stand, tapered tension control on each stand which would slightly adjust the motor field strength during a speed change, and even tension regulators utilizing tensiometers between stands. All of these steps were aimed at maintaining a better speed correspondence between stands to obtain more accurate gage of the strip during an acceleration or deceleration.

Around 1940, it became clear that one of the greatest aids to speed matching would be to compensate for the

IR drop in the motor armature circuit. This was accomplished by inserting booster generators in series with each motor with the voltage of the booster generator regulated as a function of armature current so that the IR drop was completely or partially compensated. The addition of these boosters proved to be very valuable in maintaining gage of the steel over a greater portion of the acceleration or deceleration.

As drive horsepowers became greater, it soon became economically feasible to supply an individual generator for each stand of the tandem mill. Since 1946 practically all of the large tandem mills installed have used the adjustable voltage system with individual generators per stand. Since each stand had its own generator, it was no longer necessary to supply the expensive series booster as the voltage of that generator could be slightly altered to compensate for the IR drop in that particular motor armature circuit.

REGULATING SYSTEMS

As the electrical equipment for tandem mills progressed from constant potential adjustable speed motors through common bus adjustable voltage systems and finally to individual generator systems, the requirements of the regulating systems for these mills have become more and more severe. With the common bus drive it was necessary only to have a voltage regulator on the generators supplying the bus to accomplish speed correspondence between stands. However, with the individual generator system it is necessary that the voltage of each generator be regulated to some common reference in order to maintain a speed match.

All recent tandem mills have used basically the same scheme of regulation. That is, a master voltage reference for all stands is obtained from a motor-operated rheostat. On each stand this reference is compared with the generator voltage by the voltage regulator which then acts to maintain the generator voltage equal to the reference voltage. In addition to current signal is introduced into this regulator so that the generator voltage is altered to compensate for a portion of IR drop in the motor armature. Such an arrangement has become the accepted standard and is used throughout the industry. Acceleration and deceleration of the mill is obtained by use of the motor-operated rheostat. Of course, setting up the mill to a given schedule is accomplished by the field settings on the motors, but this is not disturbed during a speed change of the overall mill.

RECENT STAND VOLTAGE REGULATORS

The following is a description of regulating systems suitable for use on stands of tandem cold mills. Perhaps some will say that there are only minor and unimportant differences between some of the circuits, yet a description of them is necessary for a complete evaluation of this type of regulator. In each case only the stand voltage regulator itself will be shown with no attempt made to show the master reference to all stands or the motor field circuit of each individual stand.

System A — The first stand voltage regulator for an individual generator variable voltage system used the basic regulator shown in Figure 1. Here it can be seen that the control field of the buck-boost regulating exciter (BBRE) compares the generator voltage to the reference voltage. This signal is then amplified in the BBRE machine to regulate the generator voltage. A current signal is amplified in the IR drop exciter (IRE) and introduced into the voltage regulating loop. It can be

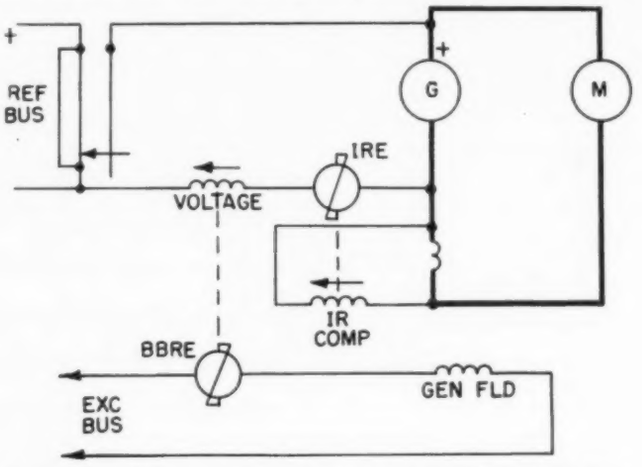


Figure 1 — System A shows the first regulator for individual generator tandem cold mills.

seen that as the motor armature current increases, the voltage applied to the field of BBRE machine increases so that the generator voltage is raised to yield IR drop compensation.

System B — Following the first regulator which was shown in Figure 1, the same machines were reconnected in a slightly different manner to obtain the regulator

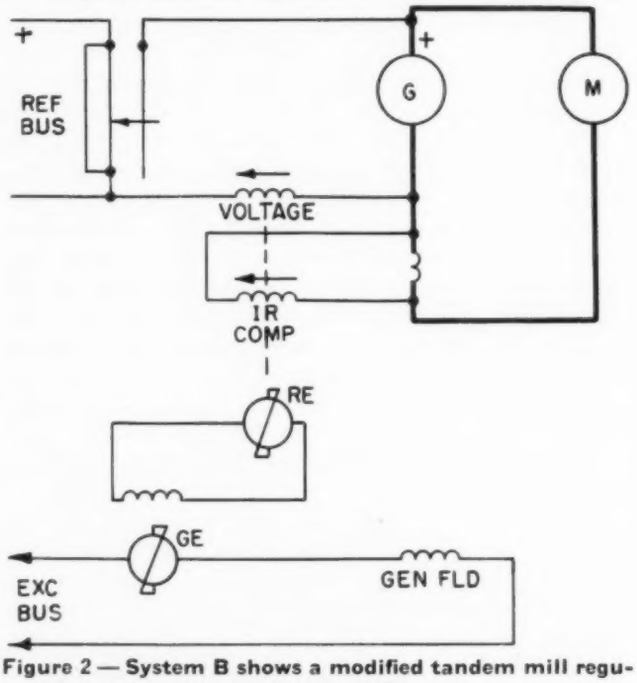


Figure 2 — System B shows a modified tandem mill regulator using two rotating amplifiers.

shown in Figure 2. The designation of these machines has been changed since their function has changed in the circuit. However, it is again seen that the reference and generator voltage are compared and amplified, but in this case is amplified in both the regulating exciter (RE) and in the generator exciter (GE). It will be noted that a current signal is introduced on to a field of the

RE machine in a direction to increase the generator voltage so that IR drop compensation is obtained.

System C — The next step in the evolution of the tandem mill regulator was to replace the small rotating amplifier with magnetic amplifiers. This circuit is shown in Figure 3. It will be seen that functionally this is the same circuit as Figure 2, however, the small rotating amplifier is replaced by two magnetic amplifiers — a regulating forward magnetic amplifier (RFA) for exciting GE in the forward direction, and a regulating reverse

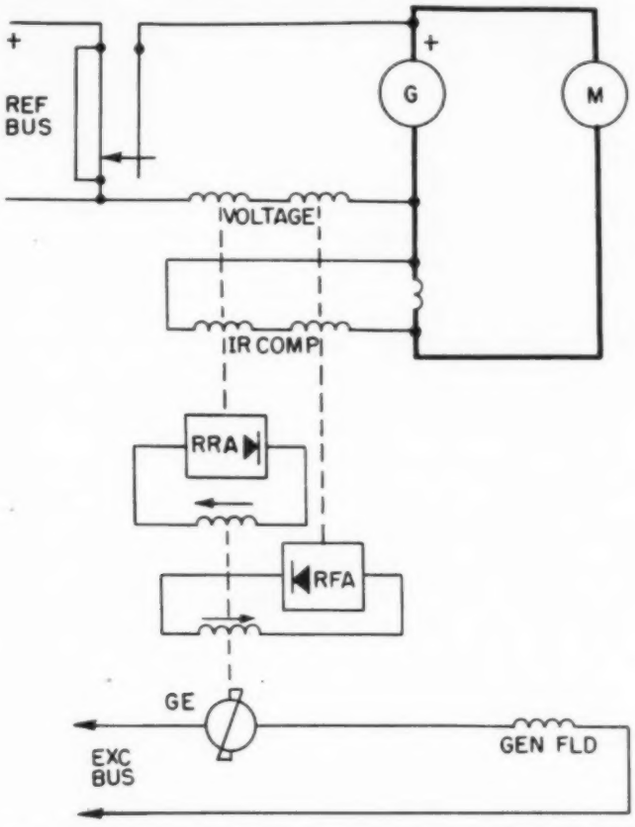


Figure 3 — System C shows a regulator with a combination system of magnetic and rotating amplifiers.

magnetic amplifier (RRA) for exciting the GE in the reverse direction. Two magnetic amplifiers are necessary since during deceleration, the GE must be driven negative to force the generator voltage down. It can be seen then that the voltage error is amplified in the two magnetic amplifiers in the GE exciter to control the generator voltage. IR drop compensation is obtained by means of a current signal on a control field of the magnetic amplifiers.

System D — In the interest of constructing an all-static regulating system for tandem mills, the system shown in Figure 4 was installed on one tandem mill. Here it is seen that the voltage error is amplified in two small magnetic amplifiers (RFA, RRA) and in two large power magnetic amplifiers — a generator forward magnetic amplifier (GFA) and a generator reverse magnetic amplifier (GRA). It is necessary to use two power magnetic amplifiers to excite the generator field since reverse generator excitation is required for forcing during deceleration. It can be seen that GFA will produce a voltage to excite the generator positively and GRA will produce negative excitation. IR compensation is obtained in much the same way as before.

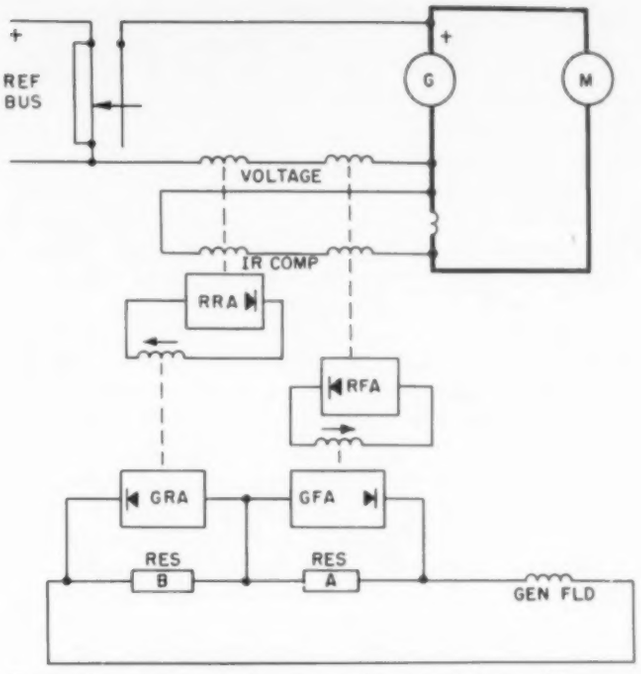
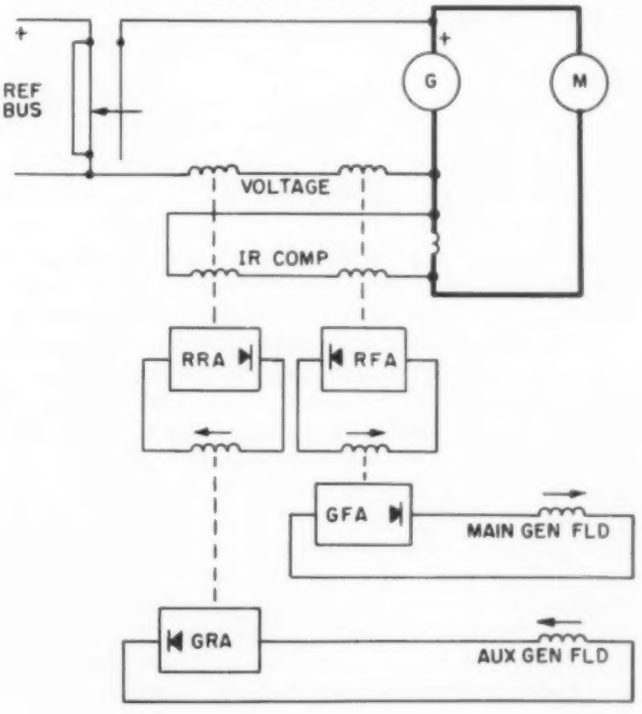


Figure 4 — System D shows an all-magnetic amplifier regulator using one generator field.

System E — A second method of constructing an all-static regulating system is shown in Figure 5. This system uses the same number and type of devices as are used in system D. However, in this case, the two power magnetic amplifiers supply two separate generator fields instead of being coupled by resistors A and B. Thus, in this case, GRA excites the auxiliary field to force the generator down during a deceleration. Since the auxiliary field is excited only for stopping or suiciding, it has only 20 to 30 per cent of the capacity of the main field. IR compensation is similar to the previous system.

Figure 5 — System E shows an all-magnetic amplifier regulator using two generator fields.



METHOD OF SYSTEM EVALUATION

The remainder of the paper is devoted to a discussion of the characteristics of the five regulators just presented. However, to do this, it seems desirable to first discuss regulating systems in general to determine what the important factors are which should be considered.

It seems safe to say that a user of electrical equipment is interested in two factors — performance and dependability or maintenance. Let us discuss these factors.

Performance — There is no simple way to describe the performance of a tandem mill regulator. It is not possible, for example, to say that one system will roll more on gage strip than another since the factors which control gage are not that clearly known. There are a few factors, however, which must have an influence in the performance of a mill. Probably the most important characteristic which should be considered is the time required for the motor speed to recover when the load is suddenly changed. If the speed of a tandem mill motor were accurately observed following the application of a load on the motor, it would appear as in Figure 6. Since only 75 per cent IR compensation is used, the speed does not completely recover, but the important thing is how quickly the speed recovers to its final value. This is defined as the recovery time.

Recovery time is important at both threading and running speeds. When the strip is threaded into a stand, the speed of the motor naturally drops and then recovers, and it is essential that any loop which is developed is quickly removed. When operating at normal running speed, the load on a motor may change due to a variation in the nature of gage of the steel. Again it is essential that the speed of the motor quickly

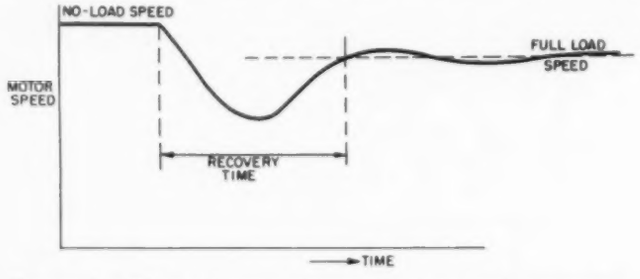


Figure 6 — Typical curve shows the drop and recovery in motor speed following a sudden application of load on the motor.

recover to reduce the effects of the change in steel. Therefore, one important factor which should be considered is the recovery time to a sudden load change. It seems reasonable that a rapid recovery is desirable.

At running speed, it is impossible to measure the drop and recovery in speed because a sudden load cannot be introduced. However, while threading, it is possible (but difficult) to record the speed drop and recovery just as the strip enters a stand.

Because of the difficulty in measuring the speed drop and recovery time, an easier test is sometimes used. In this test, the reference voltage to a stand voltage regulator is suddenly increased by, say, 2 per cent. Then the generator voltage is observed to determine how fast it will respond. The results of such a test appear as in Figure 7. Certainly this test gives some measure of regulator performance, but it is not as meaningful as recovery time. The values given later for each regulator for recovery time and response time were obtained from the analogue computor with the same motor used in every case. Since the transient performance of a regulator is affected by the motor characteristics, a clear picture of the regulators could not be given if different motors were used. However, frequent comparison of computer and test results has indicated that the computer gives very accurate results.

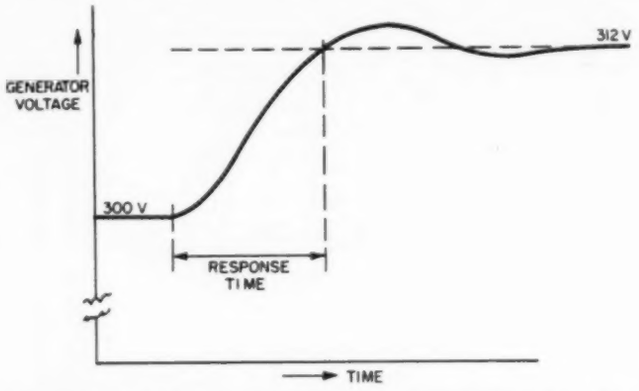


Figure 7 — Typical curve shows the rise in generator voltage following a sudden small increase in the reference voltage.

It is interesting to note at this point that these two characteristics of rapid recovery time and response time cannot immediately be detected by the operator. Since his speed vernier works on the motor field strength, the response to his vernier change does not depend on the generator voltage regulator.

It should also be pointed out that these characteristics of rapid recovery time and response time are not closely related to accurate tracking. That is, a tandem mill can be made to accelerate or decelerate with perfect speed or voltage matching with either a fast or slow voltage regulator. The only requirement is that the regulators must be adjusted properly.

A third performance characteristic which should be considered is how fast the regulator will bring the mill to a regenerative stop in an emergency. This is important both for safety of personnel and the amount of strip which leaves the mill during the stop. That is, if the strip breaks, the amount of wasted strip is reduced by a fast stop. Such a stop should be limited only by the commutating ability of the machines and not by the regulator.

Dependability — Unfortunately, this question of dependability cannot be as concisely described as performance. No precise data can be given which will tell when the next failure is expected, how long it will take to fix, or how expensive will be the repair, and yet it is clear that these considerations are important.

It seems that one of the most desirable features of any industrial regulator is a system which is as simple as possible and yet is capable of good performance. This allows maintenance personnel to more easily understand and gain confidence in the system so they can find and repair any failures. Therefore, one good measure of dependability is circuit simplicity. A second factor to be considered is how well the circuit components adapt themselves to a program of preventive maintenance. That is, since no device is completely free of failure, can

a routine periodic check indicate that failure is approaching and maintenance is necessary.

One should also consider these two factors which may have an influence on the dependability of the regulator: (1) are spare parts which are required expensive, and (2) do circuit constants change over a period of time to upset the adjustments?

SYSTEM EVALUATION

System A — This system of Figure 1 has proven eminently successful and is presently in use on many tandem mills. Experienced operators have made outstanding records on mills using this system. The first installation to use system A was a 6200-fpm, 5-stand, tandem, tinplate mill, which has produced excellent tonnage records. The 8-hr turn record is 1147 tons with a monthly average of 770 tons per turn of tinplate.

The measured performance of system A is shown in Table I. Compared to the later systems, its recovery time appears to be quite long, and yet the operators found the threading and running characteristics of these mills quite satisfactory. This system, as well as systems B and C, is easily capable of a fast regulated stop since the exciter, GE, can quickly swing negative to force the generator voltage down rapidly.

From a dependability standpoint, this system had some desirable features and some less desirable ones. First of all, it is a simple circuit with the theory of operation very straightforward. Maintenance personnel have found little difficulty in understanding and working on it. One objection to this circuit is that the IRE machine is physically small and is connected to the high voltage bus. Spare parts present few problems because each stand of the tandem mill may have the same regulating machines.

System B — As can be seen from Table I, this change to system B considerably improved the recovery time of the motor speed following a change in load. This system is in use on a 7000-fpm, 5-stand mill and performing exceedingly well. The operators accelerate to 5000 fpm in about 12 sec and decelerate to thread in about 8 sec, with the mill on gage at 1500 fpm on the way up, and off gage at 1500 fpm on the way down. The regulator is adjusted to stop the mill in an emergency in about 4 sec from base speed (4000 fpm) or about 6 sec from top speed (7000 fpm).

The dependability of system B is improved over A since the physically small exciter no longer has its armature connected to the high voltage circuit. This reduces the possibility of an insulation failure to ground. In other respects, A and B are very similar since the circuits are equally simple and easy to understand. The same machines are required in both cases making the spare parts requirements identical.

System C — As can be seen from Table I, the change from B to C has further improved the recovery time of motor speed. This increase in transient response is mainly due to an improved design of the exciter, GE, but is aided by the fact that the small rotating amplifier, RE, of system B has been replaced by magnetic amplifiers.

Again, fast stops are easy to attain since the exciter can quickly reverse to produce negative forcing. Another advantage of this system over A or B is that suiciding the generator is easier since no residual voltage is produced by the magnetic amplifiers. With the small rotating amplifier in the circuit, residual voltage of that machine made suiciding more difficult.

This system is not quite as simple as A or B since one rotating amplifier has been replaced by two magnetic amplifiers. However, since these magnetic amplifiers are small devices mounted on the rear of a standard control panel they should be easy to service or replace if necessary. In fact they should be easier to service than the small rotating amplifier which they replace.

Spare parts are no problem since these regulating devices may be duplicated on each stand.

System D — This change from system C to system D represents a major change in both components and circuitry since the generator exciter, GE, has been replaced by two large 400-cycle power magnetic amplifiers. It is necessary to use two magnetic amplifiers to obtain the required amount of negative generator field voltage when decelerating or stopping.

This system has been in operation since February 1954 on one stand of a 4-stand mill. This particular mill was supplied with a complete regulating system like system B. In addition, system D was supplied on stand 4 with a convenient means to switch back and forth between the two regulating systems. Thus, it has been possible to make a quick comparison of the two types of regulating systems. Even though the measured performance of system D is better than B (see Table I), the operators are unable to detect which system they are using.

This system was designed to have the same emergency stopping time as any of the previous systems, but in so doing, the magnetic amplifiers must be of larger capacity than the equivalent rotating amplifier and the circuit becomes less efficient since power is dissipated in resistor A under normal running conditions.

The question of dependability is one of the greatest unknowns for this system since the industry has very little experience with large magnetic amplifiers. It is obvious, however, that this circuit is far more complicated than the previous circuits. Not only has the GE been replaced with two magnetic amplifiers, but they are large, three-phase power units which must be supplied from a large 400-cycle alternator. In addition, the magnetic amplifiers must be mounted in an enclosed force ventilated cabinet. The schematic diagram of Figure 4 is a bit deceiving since the "small black box" of GFA and GRA is actually a complicated circuit.

It is difficult to say what life can be expected from

TABLE I

Calculated Performance Characteristics of Tandem Cold Mill Regulating Systems

System	Recovery time, sec (Load change)		Response time, sec (Reference voltage change)
	Full field	Weak field	
A	1.4	2.5	0.50
B	0.8	1.4	0.35
C	0.5	1.0	0.10
D or E	0.5	0.9	0.07

these magnetic amplifiers since the life of a selenium rectifier is unpredictable. There are indications, however, that even though the frequency of failure may be less with system D than system C, the job of locating and correcting troubles will certainly be greater. One feature which is often overlooked, is that it is difficult to determine how the rectifiers are ageing and when they should be replaced. With the rotating amplifier, a routine examination of the commutator and brushes will indicate if service is required. In addition, the characteristics of the magnetic amplifiers change as the rectifiers age. Since this may upset the speed correspondence of a finely tuned tandem mill, a readjustment of the regulators may be necessary after a period of time.

It may be somewhat more costly to carry adequate spares with system D than with A, B, or C. First an additional machine is desirable as a spare for the large 400-cycle alternator. Like system C, all standards could have the same regulators making one set of spares serve all stands. However, one difference between C and D is that a rotating amplifier may usually be repaired after a failure, but should the rectifiers of the magnetic amplifier fail, they cannot be repaired, but new ones must be purchased. This is not so much a factor in the small magnetic amplifiers since such small devices will usually have more design margin and are also less costly to replace.

A factor sometimes claimed in favor of system D is that installation costs may be less than A, B, or C since the magnetic amplifiers which replace the generator exciter may be panel mounted and, if so, require no mounting pad and interconnecting wiring as does an exciter set. However, in most cases the power magnetic amplifiers will probably be of such physical size that they will require forced ventilation in enclosing cases requiring more floor space and interconnecting wiring than the rotating amplifier replaced.

System E — This system illustrates another way to build an all-static regulator. In this case, two generator fields are used instead of the coupling resistors of system D. The transient performance of this system is the same as system D since here again 400-cycle power magnetic amplifiers would be used. The choice between D and E depends upon the cost of the additional generator field and the stopping time of the drive. Calculations indicate that the rating of the reverse magnetic amplifier increases inversely as the square of the stopping time and inversely as the square of the size of the auxiliary generator field. Thus, economics have indicated that for rapid stops, system D is usually preferable. Also, it is felt that the system which uses only one generator field is simpler and more desirable.

SUMMARY

It is somewhat like a novel to follow the course of development of these tandem mill regulators. It clearly demonstrates that progress is a step-by-step procedure with a thorough examination of each step to indicate the best path to follow in the future. Now that these five regulating systems have been presented, it is essential that some conclusion be drawn to indicate the best choice of regulating system.

It is often stated that engineering decisions are simple to make since they are based on clear cut facts. However, these "facts" are often not very "clear cut" and thus much judgment is required. In this case, for instance, the facts clearly show that system B is preferable to A since better performance is obtained with the same machines in an equally simple circuit. Also the facts show that the change from B to C is undoubtedly desirable since better transient performance is obtained by simply replacing the small rotating amplifier with two small magnetic amplifiers. However, the change from C to D or E does not show clearly that an improvement is achieved. The foregoing has indicated that there are pros and cons both ways. Certainly there is no appreciable difference in transient response of the mill drives. It seems to boil down to the fact that system D uses static amplifiers in a complex circuit while system C uses static and rotating amplifiers in a simpler circuit. Even this may be considered a matter of opinion, with some engineers lining up on one side and others on the other side. However, an analysis of recent tandem reduction and temper mill installations will indicate the combination system to be favored by a considerable majority.

The reason for this difference in circuits is that it is essential for a tandem mill to stop rapidly, requiring the regulator to swing negative to force the generator voltage down rapidly. Thus, two power magnetic amplifiers must be used in a complex circuit, since the magnetic amplifier is inherently a non-reversing device. With the rotating amplifier, only one need be used in a simple circuit since the rotating amplifier is inherently a reversing device. Judgment would seem to indicate the best system is one which uses a regulating device, which by its very nature, is better suited to the requirements.

DISCUSSION

PRESENTED BY

D. C. McCRADY, Superintendent Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

R. G. BEADLE, Steel Mill Engineering, General Electric Co., Schenectady, N. Y.

R. W. SHEFFLER, Design Engineer, United States Steel Corp., Fairless Hills, Pa.

I. R. ROSENAK, Chief Engineer, Inland Steel Co., East Chicago, Ind.

D. C. McCrady: In connection with the power magnetic amplifier, do you use a high frequency power supply and, if so, what type of equipment do you use to produce the high frequency? Is this used for the control amplifiers as well?

R. G. Beadle: In order to obtain the speed of response indicated for systems "C," "D" and "E," high frequency magnetic amplifiers are required. However, Mr. McCrady's question concerning the type of high frequency power supply brings up one important difference between system "C" and systems "D" and "E."

The power magnetic amplifiers of system "D" and "E" are rather larger units since they must supply the excitation of the large main drive generators. The most economical method of obtaining large quantities of high

frequency power is through the use of an alternator. The installation of system "D" mentioned in the paper employed a salient pole, 1800-rpm, 400-cycle alternator.

On the other hand, the magnetic amplifiers of system "C" are small units since they must supply only the excitation required by the rotating amplifiers. This small amount of high frequency power is obtained from a rather interesting device known as a static frequency multiplier. The static frequency multiplier consists of six small transformers which saturate each cycle and are connected in such a way that the line frequency is multiplied by six to produce 360 cycles.

Thus, this seems to be one advantage of system "C" over "D" or "E." Since only a small amount of high frequency power is required, a small static power supply may be used. However, this device is not economical for large amounts of power, and thus a rotating alternator must be added for systems "D" or "E."

R. W. Sheffler: It is interesting to note the speed with which the ideas change on methods of regulation. We originally installed system "A" at Fairless Works and before we were in operation we changed to system "B." Now, even though this mill is not very old, they have gone to system "C," "D" and "E"; indicating that the change is very rapid.

I. R. Rosenak: In his paper, Mr. Beadle has dealt with the application of these systems to existing mills as we know them today. However, we see a tendency in the future towards mills of higher speed, rolling lighter gage steel. This means that precise tension control is going to be more important on these mills; in fact, it might be that we must roll with very little or no tension in the strip because of the very light gage.

I would like to know if any one of the systems described will favor these extremely light gages and decreased tension.

R. G. Beadle: I would say that you have hit upon the very thing which has caused this evolution in tandem mill drive systems. In general, the demand through the years has been higher speeds, higher gages, more tonnage, etc. The closest I can come to answering your question is to refer back to the paper where the performance characteristic of recovery time is discussed. After a change in motor load due to a change in hardness or gage of steel, it is important that the motor speed recover quickly to prevent excessive variations in tension. Therefore, recovery time would be one measure of how these regulating systems would favor the light gages. As Table I indicates, systems "C," "D," or "E" should be superior to the previous systems.

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AISE PICTORIAL REVIEW

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Spring Conference

Detroit, Michigan

April 25, 26, 27, 1955

A total of 696 members and guests attended the 1955 AISE Spring Conference, held this year at Detroit's Hotel Statler. The traditional dinner for the Board of Directors (1) officially opened the three-day meeting.

AISE president, John H. Vohr, seated left, (2) chats with fellow officers. Standing are: Emil Kern, secretary; Leonard Larson, treasurer; James D. O'Roark, second vice president; and (seated) W. H. Collison, first vice president.

Registration desk (3) in the Statler foyer was a busy spot as "the early birds" began signing up. Authors and chairmen (4) of the initial rolling mill session hold a brief get together following the authors breakfast on Monday, April 25. Left to right are: David Lyle, Continental Foundry and Machine Co.; Wade Hoffman, Jones and Laughlin Steel Corp.; H. F. Kaiser, G. D. Angerman, and P. T. Reynolds, all of Republic Steel Corp.; and Louis Moses, Bethlehem Steel Co. Left to right in (5) are: Herman C. Inlow, Cities Service Research Development Co.; R. A. Kraus, Republic Steel Corp.; K. E. McHenry, Bethlehem Steel Co.; M. D. Ayers, Wheeling Steel Corp., and A. L. Thurman, of the Mannesmann-Meer Engineering and Construction Co. outlining plans for the mechanical session.

As usual the technical sessions were well attended. Figure (6) shows a portion of the crowd that attended the rolling mill session Monday morning.

Figures (7), (8), (9), and (10) show pre-session conferences by the various authors and session chairmen. Shown in (7) are: Don C. Horsman, Continental Steel Corp., V. W. Johnson, Colorado Fuel and Iron Corp.; and G. A. Henderson, Bethlehem Steel Co., shortly before their rolling mill meeting. In (8) S. O. Evans, Babcock and Wilcox Co.; (far right) discusses plans for the electrical session with A. F. Kenyon, Westinghouse Electric Corp.; R. T. Winterringer, Republic Steel Corp.; A. J. F. MacQueen, Algoma Steel Corp., Ltd.; R. J. Moran and H. N. Snively, General Electric Co. Details of the final rolling mill session (9) are talked over by W. J. Reilly, Ford Motor Co.; William C. Campbell, Youngstown Sheet and Tube Co., and Robert Sergeson, Rotary Electric Steel Co. (seated) and R. R. Webster, Jones and Laughlin Steel Corp. and William Pope, National Grinding Wheel Co., Inc. Participants in the combustion session (10) work out some last minute problems. Left to right they are: F. R. Pullen, Bethlehem Steel Co.; John Sprague, Ford Motor Co.; D. R. Baker and J. T. Cook of Timken Roller Bearing Co.; F. C. Schoen, Alan Wood Steel Co.; and G. H. Krapf, United States Steel Corp.

An off-the-record round table discussion (11), inaugurated this year, highlighted the two-day sessions. Panels members included: G. A. Henderson, Bethlehem Steel Co.; Alex Montgomery, Jr.; United States Steel Corp.; Chairman Louis Moses, Bethlehem Steel Co.; Don C. Horsman, Continental Steel Corp.; Charles F. Peck, Jr., Carnegie Institute of Technology.

M. D. Stone, United Engineering and Foundry Co. and L. F. Coffin, Bethlehem Steel Co. take time out between sessions to talk shop.

The inspection trip (13) to Great Lakes Steel Corp., on Wednesday, April 27, climaxed the 1955 meeting. A total of 253 men made the trip to Ecorse.

An informal stag dinner was held Tuesday evening, April 26 (14). A. E. Kadell, senior vice president, Great Lakes Steel Corp. addressed the gathering.

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Controlling Losses from Fire

By C. V. BATLEY

Insurance Surveyor, Bethlehem Steel Co., Bethlehem, Pa.

. . . . three items — fuel, air and heat — are the necessary elements of the fire triangle . . . . elimination of their combination is the essence of fire prevention . . . . it is necessary that steel plant operators and engineers continually use their talents to prevent fire and the consequent needless waste in the steel industry . . . .

▲ ABOUT a year ago there occurred a fire loss that caught the interest of the nation. The "General Motors Fire," as it became known, made the headlines. Because of the magnitude of the losses that resulted from it, one magazine called it the top business news story of the year.

Numerous reports covering all phases of the fire, the resulting losses, their effect on various suppliers, and on the general economy, were issued by individuals, boards, and associations. These reports were read in astonishment by a number of people who normally give little thought to fire losses. For a short time, at least, they became aware of the potentialities of losses by fire.

Although this fire resulted in the largest single industrial fire loss on record, General Motors was large and strong enough to survive it. Many concerns suffering large fire losses, however, are less fortunate. While these individual losses have been much smaller, they have been more serious in many cases to the firms involved. The records indicate that over 70 per cent of the firms that suffer a major fire loss of similarly destructive proportions either do not open up again or fail within a few years.

A question naturally arises when we read of a catastrophe such as the General Motors fire, and that is: "Can it happen to me?" It not only can, but is happening to the segment of industry that you represent. Excluding automobile manufacturing and shipbuilding, those engaged in the producing, forming, fabricating, or machining of iron and steel suffered a surprising number of large loss fires. In the year 1953 there occurred in this industry two fires causing losses reported at over one million dollars each; four others at over one-half million dollars each; and thirteen others at over one-quarter million dollars each. It is estimated that more than eight million dollars was lost in these nineteen large loss fires. The total fire loss for 1953 for this group is estimated at thirty to forty million dollars.

Now, let us compare that 1953 fire loss record with a pre-war year. In 1939 there was only one fire loss of over $250,000 reported by this group. The loss resulting from that single large loss fire was a little over $600,000. A very rough estimate would place the total fire loss of the industry for the year 1939 between ten and fifteen million dollars. The records of the intervening years indicate a consistent increase in fire losses up to the present high figures.

The figures quoted are based on the statistics compiled by the National Fire Protection Association. They represent only the direct fire loss to property; the indirect losses are, of course, many times larger. While every effort is made to get accurate data, it is generally recognized that these figures are conservative and probably are accurate enough only to show general trends.

It does appear from that record, however, that the iron and steel industry still has a problem of fire loss control.

Let us now consider for a moment some of the basic aspects of the problem of controlling losses by fire.

What is fire? The following definition may be helpful: fire is a chemical reaction, a form of oxidation in which some material which is called fuel, reacts with oxygen in the air, producing heat and flame. Some external source of heat is generally needed to initiate the reaction which then becomes self-sustaining. These three elements — fuel, air and heat — all of which must be present to start a fire, are often referred to as the fire triangle. Any two of the elements may exist together, without the reaction starting. The introduction of the third element is needed to start the fire.

This point is often lost sight of, and most people think only of the heat element as the cause of a fire, but in the iron and steel industry heat and air (oxygen) are normally present in many operations, and it is the introduction of a fuel that is the real cause of the fire.

As the fuel to complete the triangle is most frequently introduced by poor housekeeping, it explains why it is often said in the industry: "clean places seldom burn."

A fire hazard may be said to exist when there is a possibility of the accidental formation of the fire triangle, and a resulting spread of unfriendly fire. In analyzing fire hazards it is helpful to classify them either as personal fire hazards or as mechanical fire hazards. Personal fire hazards are unsafe acts. They are difficult to correct because they are generally momentary, and, therefore, are difficult to detect. Furthermore, people may act in an unsafe manner repeatedly without causing a fire and this makes it difficult to change their actions. Mechanical fire hazards are unsafe conditions. They may be due to construction, to storage or handling of materials, to operations, or to lack of care and maintenance. They are often difficult to correct because of the expense involved.

Wherever we have people, personal fire hazards will be present. It has been said that unsafe acts are due to ignorance about 10 per cent of the time and to carelessness about 90 per cent of the time. We all act unsafely at times. We generally know better.

The mechanical fire hazards will vary with the industry. What are some of the hazards we find in the iron and steel industry?

Unfortunately, construction is not so non-combustible as it first appears. In the older plants there are still large wooden-roof areas. In some of the newer construction, asphalt-protected metal has been used extensively for roofing and siding of structures because of its low maintenance cost and long life. While the newer types of this material are much less combustible, there are many large-area buildings in which the older type has, under certain adverse conditions, contributed to major fire losses. Moreover, many of these older plants are congested and fire-fighting forces are hampered in getting to and in fighting fires.

Large quantities of fuel, mainly gas or liquid, are used in the numerous large heat producers. The storage of these fuels is often intermingled with operating buildings without adequate space or other separation because of the congestion in old plants that have just grown. In other instances, safer storage has been arranged for. Other combustible oils are used for lubrication, for hydraulic fluids, for tempering oils, for finishing oils in rolling operations. These materials are often stored in basements. Some are reclaimed or reprocessed. Gases such as acetylene, propane and butane are used in specific operations. These combustible liquids and hazardous gases are used throughout the plants, are often present in large quantities, and may be in localities where leaks or spillage are nearly always certain of being ignited from radiated heat or sparks from heat producers or from heated or molten metal or slag. The hazards involving those liquids and gases probably constitute the greatest single classification of fire hazards in these plants.

The next serious fire hazard involves electricity. Large amounts of electricity are generated, transmitted and ultimately used for power and light, and, in some cases, for heat. Due to the nature of the operations, this equipment is subject to abuse. Good housekeeping and good maintenance are difficult and, with the large expansion programs undertaken by the industry during the last few years, it is a constant race to keep electrical equipment from becoming overloaded. Electricity presents a real potential hazard throughout the plant, which only a good program of preventive maintenance can control.

There are numerous spot hazards. The benzol plants are producing more and more refined products and are rapidly becoming full-scale chemical operations. Here we are dealing with extremely hazardous materials and here the problem of loss control is becoming more difficult, because fire extinguishing media are sometimes selective in their ability to extinguish fires in these various chemicals. Pattern, template and carpenter shops; and pattern, template and lumber storage are other spot hazards that can give trouble. Other maintenance shops store and use paints and combustible gear and parts. Because of the nature of the operations, employees quite generally change into work clothes, so locker rooms full of clothes are common. In these plants, thousands of people are employed who necessarily must work around heat producers, spark producers, molten and heated metal and slag, and, in the terms of the fire triangle, people are fuel.

In setting up a program to control losses by fire, it is self-evident that the best way to stop having fire losses is to stop having fires. That is the first objective. The second objective is to build and operate in a manner that will prevent the spread of fire if it does start. The third, and last, is to be prepared to handle with a minimum of loss the fire that "gets away."

Accomplishing these three objectives is fire protection.

Large segments of the iron and steel industry are urgently promoting these fire protection programs. While these programs vary widely in different companies and in different types of operation, those that are effective contain the following common fundamentals:

1. *Placing clear-cut authority and responsibility for the program in one person.*

   This seemingly obvious step surprisingly is often overlooked, with the result that many programs fail.

2. *Knowledge of probable and potential fire hazards.*

   The highly specialized knowledge of fires, fire hazard and fire protection must be secured to guide a successful program. This knowledge may be obtained by any competent engineer from the study of the wealth of material available on this subject, or the services of an engineer already trained in this field may be secured by direct employment, or through the courtesy of the company carrying the insurance. The way this knowledge is made available is of minor importance as long as it is adequate to do the job. It is also essential that this knowledge of fire protection be coordinated with the other specialized knowledge in the industry, the knowledge possessed by engineers, operators, maintenance and service personnel, and safety personnel.

3. *Detection of the fire hazard.*

   The actual and existing fire hazard must be found in the plant, the potential fire hazard must be recognized on the drawing board or in the planning stage. This means the plants must be inspected regularly and consistently by competent in-

spectors. It means the closest of cooperation between those planning expansion and changes in the plants, and those having the knowledge of fire protection.

4. *Selection of proper corrective steps.*

   Having detected an actual fire hazard in the plant or having recognized a potential fire hazard in plans of changes or expansion, a course of action must be determined that will eliminate the hazard or control the possibility of fire with a minimum of loss. There are available good answers to most of the problems or hazards that will be encountered and the proper course may be self-evident. In other cases, the help of the specialized knowledge possessed by people in other fields, such as engineers, operators, etc., will be essential to determine what corrective steps should be taken. A suggested course of action should always be checked to see first, that it will actually accomplish the desired purpose, and second, that it is practical. This sounds rather obvious but again and again one or both of these factors seem to have been lost sight of when recommendations are made.

5. *Application of the selected corrective steps.*

   If the hazard is to be eliminated or controlled the selected corrective steps must be taken. Here those charged with loss prevention may have to sell their ideas to those who control the purse strings. This is not always easy, but if the corrective steps have been properly selected, that is, if they will accomplish the purpose and are practical, both in respect of method and economic justification, it should be a simple matter to sell the need of them to any competent engineer. Thus the aid of the engineers, operators, maintenance and service personnel or safety personnel can be secured in getting the necessary money.

These programs throughout the industry have accomplished much. The cooperation between those charged with the programs and various other engineering, operating and maintenance groups has resulted in the elimination and control of many hazards. Some of the typical steps that have been taken are as follows:

Training is the basis of any fire loss prevention program. It takes many forms. For the general employees it may be an exhibit at a safety meeting, posters, a talk and demonstration, or it may be training by doing — that is, actual use on a test fire of an extinguisher or other devices that an employee may be expected to employ on accidental fires of similar nature. As a result of such a program in one company, 95 per cent of the starting fires are extinguished without loss by these trained plant employees. That training is also essential to correct the personal fire hazards — the unsafe acts.

Private fire brigades are common in many plants. They may be fully paid, volunteer, or a combination of paid and volunteer firemen. They may be trained to act with public fire departments, but where such public departments are not available, the private fire brigades constitute the sole fire-fighting force. Training of these men is essential and these private brigades have prevented many serious losses. Formation of effective private fire-fighting forces is one way to stop the fire that "gets away," with a minimum of loss.

These plant fire brigades or departments in the iron and steel industry are often equipped with the latest and best developments in motorized fire apparatus. One company alone has over 200 pieces of such equipment in service. This equipment may be highly specialized for, in addition to standard fire department pumpers, there are foam trucks, dry chemical trucks, and carbon dioxide trucks, some of large capacity, in use in the industry.

To control fires with a minimum of loss, automatic fire extinguishing systems are installed where they are most effective. They include automatic sprinklers, water-spray and foam-spray systems, carbon dioxide systems, and dry chemical systems. Some of them are extensive and represent major expenditures. These systems are often the only answer we have to minimize hazards which cannot be eliminated.

In spite of all this, the indications are that losses are actually increasing in the industry.

Why have these losses by fire increased? It has been demonstrated that they can be controlled. The companies that have low fire loss records are invariably those who follow the basic fundamentals of fire protection. It can only be concluded, therefore, that some are not following these fundamentals.

This is primarily the fault of those in fire protection engineering work. We have not entirely sold the operators, management, and engineers. Not all have been convinced that fire loss prevention is part of his job, that it is basically his problem. In the iron and steel industry, is not anything that can cause an unscheduled shut-down and stop production the problem of the engineers of the industry?

Interest, thinking, ability — all are vitally needed if the fire losses in the industry are to be reduced. Aid is needed in detecting fire hazards, in determining the corrective steps to take, and in getting these corrections applied. Original and constructive thinking, the thinking that only the engineers with specialized knowledge of construction, operation, and maintenance can supply, is urgently needed. With all of the information that is available, we still need better answers to many problems.

As examples, let us turn again to the General Motors fire. Most men are familiar with the magnificent job that was done in getting back into production. It was an engineering feat that aroused everyone's admiration — but, if that amount of effort and ability had gone to work *before* the fire on the problem of controlling possible fire losses, corrective steps undoubtedly would have been taken that would have prevented the large loss which was suffered. Has the steel plant engineer thought about the possible losses by fire in the buildings or areas which is his responsibility? This type of thinking is necessary if losses are to be controlled.

An example of a problem which has as yet had only an unsatisfactory or partial answer is illustrated in this fire. How can the large losses by fires in large single area buildings be prevented?

For years fire losses have been controlled by the separation and division of values by physical fire barriers, and/or by means of automatic fire extinguishing systems. Industry is now demanding, in the name of efficiency, much larger single areas containing immense values, and in many cases buildings so designed that the automatic protection now available is not fully effective.

How are fire losses to be controlled in such buildings?

If what happened in the General Motors fire is reviewed perhaps a better idea of the problem can be obtained. Because of the type of combustibles involved, large amounts of heavy black smoke were produced. This smoke and the heat generated by the fire started upward and, when trapped by the roof, mushroomed. The occupants, including those fighting the fire, were driven outside and were kept outside by this smoke and heat until the fire practically burned itself out. It was estimated that the outside hose streams penetrated into the building about 75 ft. When it is realized that the smallest dimension of this building was slightly over 850 ft, these outside streams obviously had little effect. This is the type of thing that has happened repeatedly in these large area buildings.

If the heat and smoke could have escaped, fire fighters would have been able to reach the fire and a modern, well-equipped fire department would have had control in a matter of minutes. Of course, various interested bodies are trying to develop answers to this problem. The possibility of a similar fire following the lines of the General Motor fire is a problem that some operators have. If corrective steps are suggested, only the operator can judge whether in his particular case they are practical. Your help is needed to solve this problem satisfactorily.

A fire protection engineer plays many parts. Three at least are essential if he is to be effective. First, he is a reporter; he must leave a record of what he sees. Second, he is a technical expert; he must have special knowledge that will enable him to make constructive suggestions. Third, he is a missionary; he must convince others to act. As one reflects upon the staggering fire losses this country suffers year after year, in 1953, over one billion dollars direct property loss, and many billions more in indirect losses, as well as 12,000 lives lost, it is easy to understand why a fire protection engineer is a missionary. For he knows that most of these losses can be prevented; he knows that the waste of life and property, the suffering, the business failures, the loss of jobs that fire causes — can be stopped.

That is why the operators talents and knowledge should be used to accomplish this end, to think and to act; to take part in stopping this needless waste in industry. It cannot be stopped without help. It is his problem to seek its solution.

DISCUSSION

PRESENTED BY

R. H. FERGUSON, Assistant Director of Industrial Relations, Republic Steel Corp., Cleveland, Ohio

A. L. SCHROEDER, Superintendent — Field Forces Dept., Inland Steel Co., East Chicago, Ind.

C. V. BATLEY, Insurance Surveyor, Bethlehem Steel Co., Bethlehem, Pa.

R. H. Ferguson: I would like to stress the economic picture just a little bit more, because too often there are many in the steel industry who do not quite realize what these fire losses actually mean to industry. We, as the engineers who are building, designing and operating these plants, do realize the importance of the economics of fire loss but sometimes when we come to design the plant or change an operation or rebuild, some of us do not have quite the fortitude to lay it on the line from the practical standpoint as to exactly what should be done. We do know how to arrive at the right conclusion.

Mr. Batley expressed it quite well when he said that these are the things that must be done if we are going to bring fire losses down. I would like to quote just a few figures.

Fire losses for the industry in 1953 were estimated at between $30,000,000 and $40,000,000 compared to a total loss of between $10,000,000 and $15,000,000 in 1939.

It is important to note that because of our increased production capacity, new process and increased production, we are more and more being faced with losses from fire. As Mr. Batley said, fire protection and fires are not free. Somebody must pay. Believe me, we will all pay.

On prevention, if we engineer properly, if we improve design in all types of building and equipment, we will help ourselves immensely. We probably will not go through the operation and put in all the frills that some engineers would like, but we can be practical. Generally we have at our fingertips the services not only of our own engineers but the engineers of the insurance companies and people trained in fire prevention to help do this kind of work.

I would like to say this, I do not believe the prevention of fire in the plant is simply a matter of water and sprinklers. There are a lot of other things that go along with prevention. I am glad he mentioned protected metal. There could be considerable discussion on that. I think the newer types of protected metal have brought about a different kind of hazard and different preventive measures are necessary. You and I know that there have been several serious fires from the improper handling of structures of that type.

Combustible liquids can easily be handled from a fire hazard standpoint when tankage, carriers, etc., are properly designed and protected from fire and explosion. Since our tanks are used for the storage of various types of flammables, the proper construction, the proper relief and venting, and the proper fire protection are most important. Might I add that manhole openings should be standardized at 30 in.

These things are typical of the situations that Mr. Batley pointed out, and you can call in the experienced fire engineer to help in designing the proper kind of protection against a specific type of fire or explosion.

I sometimes wonder how far we as engineers follow and check the kind of fluids that are used in transformers and air filters. I know that we experienced a rather serious fire not too long ago when we had an oil line break, causing a severe loss to a big transformer. The fire caused a partial plant shutdown. Investigation disclosed that several things could have been done to correct the hazard.

In passing, Mr. Batley commented on the fact that there is often a fire hazard from the clothing that the men wear in the plant. If you go back and check some of the fire losses you have experienced in locker rooms where men have stored oily and greasy clothes, you get an idea of the losses about which he speaks. There is not only the loss of clothing in the locker room, but there is also the industrial relations problems that go with fires of this kind.

One of the greatest causes of fire is through the improper use of cutting and welding equipment. In our own organization we have a set of instructions not only for our own people but for outside contractors who perform work for us in our plants. If the right kind of preventive measures are taken, we can save ourselves thousands and thousands of dollars every year.

It is absolutely essential that the general manager, the top man in the plant, assume the responsibility for fire prevention, and I do believe you must agree that it is a basic operating problem. If you think that you, as an engineer or operator, can forget about fire prevention, wait until you have a fire and a plant or department is shut down. Then it will be found where that responsibility lies. Consequently, I believe if the job has been properly engineered, if the operation has been designed properly, if you have the right kind of prevention and fire fighting set up, you will have done much to prevent fires. We can do this kind of a job with a better preparation.

Mr. Batley also touched on the matter of inspection. I believe inspection must be carried on not only by the operator and the supervision, but it also has to be done by specialists regularly. It is essential to bring about the right kind of education of supervision and of men on the job.

One other point, many of us have outlying plants where in-plant motorized fire fighting equipment is limited. You have to depend upon local or public fire departments. Work with these authorities and train them to work with you. Thus, they will know your hazards and can be of real help.

A. L. Schroeder: Mr. Batley and the previous commentator painted a very black picture of the results of the engineers' work. I do not feel exactly the same way about it. It was mentioned that in 1939 the fire losses were between $10,000,000 and $15,000,000 and in 1953 they were between $30,000,000 and $40,000,000. I believe that if you would correct the 1939 dollars to the 1953 dollar value, and if you would correct the exposure from the 80,000,000 tons per year that we had in 1939 to 124,000,000 tons per year as we now have, you would find that the steel industry is making an improvement. However, it is not an improvement which should make us complacent.

Most of the steel plants have deductible insurance policies and may not report fires of less than $500 or $1000. These small fires are a great proportion of all the fires, and I imagine their total value would be astounding. I do not know whether Mr. Batley has included an estimate of those losses in his figure. I wish he would comment on that later.

You will find the fire engineers like to take the electrical engineer to task occasionally for overloading lines, and they watch this very carefully. I think that equally important is the overloading of water lines. We expand the building. We add more load to the electric lines and thereby increase the hazard. We also add a big water load. However, we do not increase the size of the water mains, and when you do want to use them for fighting fires you do not have pressure. The water system should be looked at just as critically as the electrical system.

The use of oxygen in the steel industry has been expanded greatly in the past three years. Some plants have complete systems with storage facilities and distribution facilities. There are several cases on record of very serious accidents in oxygen valve pits where the workmen's clothing caught fire with no apparent means of ignition other than the chemical reaction of the oxygen on their clothing.

There are a number of valve pits in our system. We have them both on the pipeline leading from the supplier's plant and in our distribution system. We also have a very rigid system of purging and testing before the men are allowed to go into the oxygen valve pits. We also ask that they wear newly laundered clothes before they go into the pits, to be assured there is no trace of oil or grease on them. I am sure that other companies have the same problem and have the same exposure, and that they have given it a lot of thought. In the safety end of the steel industry, we have the seven-company exchange which does a good job in exchanging case histories of accidents. I wonder why we cannot have the same sort of setup with our fire inspectors or our fire departments. Most of our plants are large enough to have fire departments of their own. I am sure if we did that, and these problems were brought to the attention of the engineers, they would find the answers for them.

C. V. Batley: First, I would like to thank Mr. Ferguson and Mr. Schroeder for amplifying certain of my statements and emphasizing some of the specific items of fire protection that merit your serious consideration. There are many ramifications to this problem.

The fire loss statistics I used are based on the records of the National Fire Protection Association, which are considered to be the most accurate available. They are, however, only accurate enough to indicate trends, and any interpretation of statistics of such accuracy will always be open to question. We seem to agree, however, that our losses are still too high. Further, I feel that there is conclusive evidence that large loss fires are increasing in number in the metalworking industry. No matter how we may interpret the statistics or attempt to justify the larger dollar losses which are now occurring, this increase in the number of large loss fires is one that should give us concern. It is one of the points I tried to develop in my paper.

I wish we had better statistics on the small loss fires. As Mr. Schroeder pointed out, because of insurance practices, they are largely unreported in the iron and steel industry. We have tried for some years to develop such a record in our company. We have enough data to justify Mr. Schroeder's opinion that over a year's time these small losses in total represent a rather surprising amount.

I also feel it would be of great help if the fire protection people in the iron and steel industry could establish closer and more frequent contacts. Perhaps through this Association of Iron and Steel Engineers such contacts could be developed. I think it would be well worthwhile to pursue this idea.

Mr. Ferguson brought up one factor that is a roadblock to any real progress. As he indicated, too many people think of fire protection in terms of water and sprinklers. One of the major jobs is to make people realize the complexity of the problem, that there are many factors that must be considered. This is basic. Only when the problem is understood will we make any real headway towards a satisfactory solution.

Rapid Method of RELINING a Blast Furnace

By BRUNO VEZZANI
Works Engineer
Donora Steel and Wire Works
American Steel and Wire Div.
United States Steel Corp.
Donora, Pa.

. . . . the unusually fast performance of relining this blast furnace was accomplished primarily because of excellent advance planning and wholehearted cooperation between the various groups on the job . . . . as a result, relining of furnace was accomplished in the short time of 15 days 9½ hr . . . .

▲ THE American Steel and Wire Division of United States Steel has two blast furnaces at Donora, Pa. No. 1 furnace has a hearth diameter of 19 ft-0 in. and a rated capacity of approximately 652 net tons per day. No. 2 furnace has a hearth diameter of 18 ft-6 in. and a rated capacity of approximately 652 net tons per day. Both furnaces were built in 1904 for the Union Steel Co.

The history of the campaigns of No. 1 furnace is shown in Table I.

Early in 1953, it was decided that it would be economically advantageous to reline No. 1 furnace from the mantle up. As shown in Table I, the 12th campaign had started in January 1949, and an estimate indicated that a total of 1,000,000 net tons of iron would be produced sometime in June or July.

Production for 1952 had been comparatively low and at an abnormally high coke rate. We were aware that the top of the stack lining was deteriorated and test drilling indicated that the lining was in general irregular and in poor condition.

Meetings of engineering, maintenance, and blast furnace operating personnel developed the probable amount of brick work that would be required, the contemplated repairs to the furnace and auxiliaries, the necessary replacement of castings and equipment, and in general the proposed method of procedure.

PROPOSED BRICKWORK

During the previous relining a carbon hearth up to the cinder notch had been installed and no repairs were

TABLE I

Campaign number	Blown In	Blown Out	Product in net tons	Changes in lining (Subsequent to blowout date)	Down time
1	1- 3-05	8- 1-06	322,682	Relined completely	
2	9-13-06	10- 5-07	201,755	Relined from mantle up	43 days
3	12-27-08	4-30-11	405,487	Relined completely	Furnace down
4	7-10-11	7-31-13	350,627	Relined completely	72 days
5	9-26-13	5-23-14	104,216	None (business depression)	58 days
5	1-15-15	3-11-16	211,151	Relined completely	Furnace down
6	6- 7-16	3-31-19	570,978	Relined from mantle up	89 days
7	7-23-19	12-19-21	383,155	Relined completely	115 days
8	2-21-23	5-31-24	258,811	Lining repaired	Furnace down
9	11-21-25	10- 7-27	393,010	Relined completely	Furnace down
10	8- 1-28	10-27-30	532,007	Relined completely	Furnace down
11	1-18-41	11-15-48	2,002,631	Relined completely	Furnace down
12	1-13-49	7- 5-53	1,041,209	Relined from mantle up	60 days
13	7-20-53	.....	.....	.....	15 days 9½ hr

contemplated except relining the tap hole and repairing the cinder notch. Except for patching as required, no repairs were planned for the bosh section. It was decided that the inwall and top would be lined with first quality fireclay brick as we did not believe we could justify the premium cost of cone 18 brick for a mantle-up lining.

Four rows of inwall copper cooling plates were to be replaced and partial replacement of the nodular iron castings used for stockline wearing plates was planned. The offtakes were to be relined from the elbows to the bottom of the Y and miscellaneous brick repairs were to be made to the bustle pipe, tuyere stocks and elbows, and gas mains as required. No extensive dustcatcher repairs were thought necessary.

No extensive stove repairs were planned and only the necessary relining and patching of hot blast valves and hot blast piping was contemplated.

PROPOSED MAJOR MECHANICAL REPAIRS

Preliminary inspections indicated that the furnace shell was in fairly good condition. No hot spots or abnormally high temperatures were encountered on the stack shell during the campaign and no blisters or cracks were evident.

The large bell, the one piece hopper, as well as the furnace top had been replaced during the previous relining and showed no evidence of excessive deterioration.

It was planned to renew the small bell, bell rod, and lower hopper sections, one skip car was to be replaced, two new gates were to be installed on the coke braize system, and a complete centralized lubrication system for the furnace top was required. The thermal expansion valve was to be removed and refurbished.

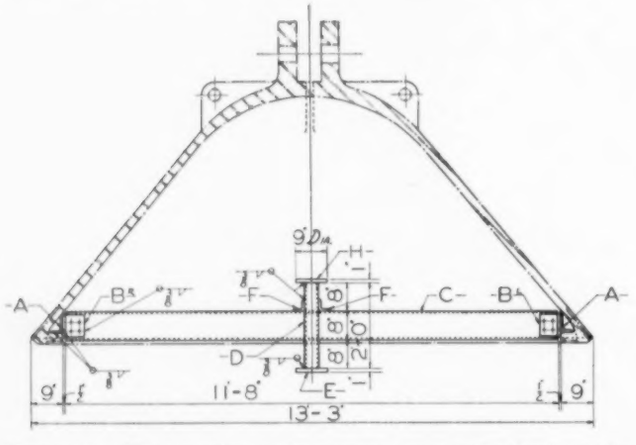

Figure 1 — The center pole support was attached to the cast-in machining lugs on the underside of the bell.

PROPOSED METHOD OF PROCEDURE

During the early January 1953 discussions, it was hoped that the mantle-up reline could be accomplished in about 22 days and rough schedules as well as work procedures were established. For example, it was decided at one of the preliminary meetings that rather than remove the big bell from the furnace top, we could lower it to the hearth before the tear-out and use its sloping sides as a chute for material to flow out of the tuyere openings, then cable it up during the relining.

We later realized the greater advantage of having it cabled in position under the big hopper and attaching the center pole support to the cast-in machining lugs on the under side of the bell as shown in Figure 1.

To hang the tear-out scaffold, it was planned to erect a small platform on the outer shell below the top deck at an elevation two feet below the big bell hopper, and cut an opening through the furnace to insert scaffolding materials.

Two inch spacers were to keep the big bell from the hopper in its temporary cabled position. Steel cables through this 2-in. "crack" would support the tear-out scaffold until the brickwork above the wearing plates was removed.

It was then planned to cut segments out of the top deck casting, resupport the tear-out scaffold through these holes, then cable the big bell tight against the big hopper, and install the center pole support.

Wearing plate castings were to be hoisted through the holes cut in the top. Tear-out debris was to be raked out of tuyere openings and bulldozed to railroad cars on the ladle tracks.

To facilitate the removal and installation of our large inwall cooling plates, a hole was to be burned in the furnace shell above the top row of plates.

PLANNING AND ORGANIZATION

With this basic information established, a cost estimate was prepared, an appropriation request submitted, and organizational plans for the relining were established.

At the works level, the American Steel and Wire Division has a division superintendent who has charge of all engineering and all maintenance. On appropriation projects of this type, the engineering department performs essentially the functions of a general contractor. With the division superintendent and general master mechanic, it determines what work can be handled by the maintenance divisions and what work should be contracted either for economy or unavailability of adequate numbers of craftsmen at the time of construction.

Hoping to accomplish this work in 22 days, it was deemed necessary to work on a 24 hr per day, seven days per week basis. The maintenance division certainly was not staffed for this drain on its personnel, so specifications for competitive quotations from outside contractors were prepared to cover the major items of relining.

For example, specifications based on the recommendations of the blast furnace committee were prepared for all phases of brickwork. Other work to be contracted outside would include: major structural repairs and high boom crane service, the installation of the centralized lubrication system, building of a new skip car, refurbishing of thermal expansion valve, etc. Work that was not given to outside contractors was in effect "contracted" to the maintenance division by means of shop orders.

Organizationally, the engineering department was responsible for the coordination, scheduling, expenditure control, and adequacy of all work performed, the master mechanic of the blast furnace division coordinated all the efforts of the maintenance divisions, while the blast

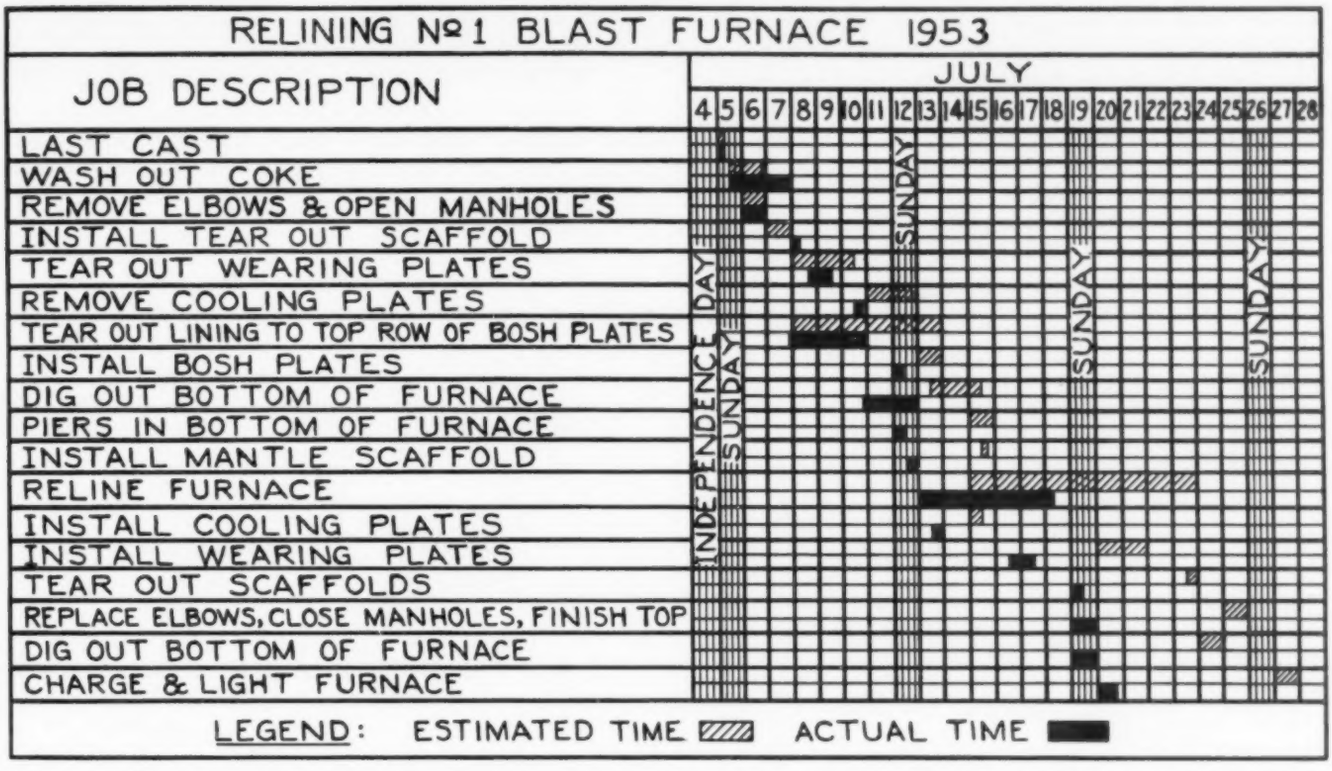
RELINING Nº 1 BLAST FURNACE 1953
JOB DESCRIPTION
JULY
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
LAST CAST
WASH OUT COKE
REMOVE ELBOWS & OPEN MANHOLES
INSTALL TEAR OUT SCAFFOLD
TEAR OUT WEARING PLATES
REMOVE COOLING PLATES
TEAR OUT LINING TO TOP ROW OF BOSH PLATES
INSTALL BOSH PLATES
DIG OUT BOTTOM OF FURNACE
PIERS IN BOTTOM OF FURNACE
INSTALL MANTLE SCAFFOLD
RELINE FURNACE
INSTALL COOLING PLATES
INSTALL WEARING PLATES
TEAR OUT SCAFFOLDS
REPLACE ELBOWS, CLOSE MANHOLES, FINISH TOP
DIG OUT BOTTOM OF FURNACE
CHARGE & LIGHT FURNACE
INDEPENDENCE DAY
SUNDAY
SUNDAY
SUNDAY
SUNDAY
LEGEND: ESTIMATED TIME
ACTUAL TIME

Figure 2 — Work schedule is shown on the chart which also gives a comparison of the estimated and actual times for completing the various phases of the work.

furnace operating division through a liaison man made certain it was getting the type and scope of work originally contemplated. These three divisions worked as a unit displaying a most remarkable cooperative effort.

PREPARATIONS

During January, all purchase requisitions were prepared to cover not only contract work but the myriads of miscellaneous materials required for a relining. These requisitions were tabulated on a special form listing the commodity, order number, supplier, date required, promised delivery date, and actual delivery date.

From this time until completion of all deliveries, a special expediter from our Cleveland engineering organization worked with the purchasing department and submitted weekly reports to the works engineering keeping the tabulation of requisitions up-to-date to insure satisfactory delivery.

Most material was requisitioned for delivery not later than June 15, 1953, except the stack lining which was to be delivered on the required dates to avoid the cost of double handling.

Of course, if all delivery promises were maintained, relining on schedule would be a simple matter. A good share of the credit of our record performance can rightly be given to our Cleveland engineering expediter who diligently pursued some of our orders to an almost better end.

Late in June 1953, all the interested personnel again met in a series of final planning and scheduling meetings. By this time, most deliveries had either been made or fairly well committed. A definite blow-out date of July 5 and a tentative blow-in date of July 27 were established.

A detailed schedule by days and hours was worked out beginning with June 30 preparatory work until the "blast-on." An outline of the salient points of the schedule is shown by the shaded blocks on the progress report in Figure 2.

The furnace was to be blown out with the small coke method. Top temperatures would be maintained and the coke quenched by water sprays installed through the dome under the big bell hopper. Top spray water was to be metered and carefully controlled.

CHRONOLOGY AND DETAILS OF RELINING

June 30 — No. 1 furnace shut down for reline preparation.

8:22 am to 4:05 pm

a. Drilled holes through dome for water sprays. Pipe work for sprays installed.
b. Furnace top cleaned of all debris and inflammable material.
c. Top fire rods installed.
d. Prepared rig for hand gage rod.
e. Installed platform on furnace shell, below deck.

Inspected and fixed sewers to handle wash-out water.

Prepared and laid out wash out troughs.

Prepared spacers for big bell.

July 2 — cleaning charge.

7:00 am —

30,000 lb Converter mill cinder.
30,000 lb Scrap.
6 Extra coke skips.
Safety meeting on reline.

July 3 — Cleaning charge.

7:00 am —

40,000 lb Converter mill cinder.
30,000 lb Scrap.
6 Extra coke skips.
Ran furnace lean —0.050 sulphurs.
Safety meeting on reline.
Brickwork contractor moved in scaffolding material.
Structural contractor moved in traveling crane and boom.
Assembly started.

July 4 — Cleaning charge.

7:00 am —

40,000 lb Converter mill cinder.
6 Extra coke skips.
Safety meeting on reline.
Following items inspected:

a. Tools for pulling tuyeres, coolers, etc. Scrapers for rake out, supply of bars.
b. Steam lines to washer and dustcatcher.
c. Mechanical goggle valve on No. 1 gas main inspected and oiled. (Valve isolates No. 1 gas mains).
d. Removed one-fourth of weights from both bleeders.
e. Spacer bars on hand for big bell.
f. Installed mercury "U" tube on top pressure.
g. Checked water meter and top spray installations.

10:00 am — Blast off to install sprays just below lower edge of big bell.

11:00 am — All scrap taken off.
Replaced scale with ore and limestone.

12:30 pm — 800 lb Limestone taken off.
Pulled dustcatchers dry.

1:00 pm — Started increasing tap hole angle to obtain maximum angle at 5:45 am.

4:30 pm — Started coke blank (nut coke — size plus 1 in. minus 2 in.).
All electrical power cut off top.
Put steel plate on ¾-in. coke screens 4000 lb per skip — 214 skips.
Dumped every 5 skips.
Maintained maximum top temperature — 400 F.
Maximum water was 60 gpm prior to shut down.

6:00 pm — Reduced wind.

6:30 pm — Cut heat from 1000 - 900 F.

6:55 pm — Finished cast.

Si 1.79	S 0.039	Mn 1.79

7:00 pm — Pulled dustcatchers — dry.

8:00 pm — Reduced wind.

10:00 pm — Reduced wind.

10:50 pm — Finished cast.

Si 1.36	S 0.063	Mn 1.68

July 5 —

5:45 am — Started last cast. (one-eighth ladle of iron).

6:21 am — Blast taken off furnace.

6:25 am — Spacer bars between big bell and hopper hung in place.
Gas seal doors left off, bells open, bleeders open.
Blow pipes were dropped and tuyeres sealed with clay and sand. No. 2, 4, 8 and 10 tuyere stocks were dropped and coolers pulled. Safety plates were installed in openings.
Wash out troughs were installed.

8:55 am — Mechanical goggle valve was closed, isolating No. 1 furnace gas mains.
Brickwork contractor erecting shanties and preparing for tear out.
Structural contractor assembling crane boom.
Water started on top and safety plates taken off 2, 4, 8, and 10 tuyeres. No one allowed in cast house or on top of furnace.

5:30 pm — Water appeared at tuyeres. Started washing coke out of 2, 4, 8, and 10 tuyeres.

July 6 —

12:00 am — Coke not washing out uniformly. Many large pieces were coming out of all four tuyeres.

1:45 am — Stock down 45 ft from original 6-ft stockline.

7:00 am — Maintenance men took out hot blast valves, blow off valves, etc. Also began to renew defective piping to stove valves.

12:00 m — Daylight was seen through tuyeres. Steam was cut off and dustcatchers opened.
Structural contractor and maintenance men started lowering material from furnace top. Offtake elbows removed, manholes in top deck and side of furnace were opened. Holes were cut in top deck.
Big bell secured in open position with cable. Hole cut in side of furnace at top.

9:00 pm — Started to dig brick out under deck.

July 7 —

Eight shots of dynamite shot to clear bosh and break up large pieces to facilitate removal through tuyere openings.

9:00 am — Installed tear out scaffold in top of furnace.
Stove tops opened for inspection. Furnace top cleared of debris.
Contractor loading brick for furnace.
Maintenance men replaced door frames and hot blast valve seats on No. 2 and No. 3 stoves.
Pipefitters working on coke breeze bin lines, and on stove piping.

1:30 pm — Fired five shots of dynamite to clear bosh. closed big bell and tightened cable.
Installed center pole support under big bell.
Pipefitters removing piping on plate coolers, tuyeres, etc.
Thermal expansion valve disconnected and lowered to ground preparatory to shipment for refurbishing.

3:00 pm — Contractor cutting brick out at top of furnace.
Top castings lowered to ground by structural contractor.
No. 1 stove door completed.

4:15 pm — Fired 6 shots of dynamite to clear bosh.

9:00 pm — Contractor removing brick. Men working under very hot conditions.

July 8 —

Contractor knocking out brick with hand bars and air hammers at top. Furnace was very hot.
Thermal expansion valve shipped out of plant by truck.
Maintenance men replacing doors for hot blast valves.

10:00 am — Dr. Roland B. Snow of U. S. Steel Research Laboratory inspected furnace lining.
Contractor worked on tear-out scaffold.

Fired dynamite in dustcatcher to loosen up accumulations.

12:30 pm — Bustle pipe inspected as well as connecting elbows — found in satisfactory condition.
Flues under stoves were also inspected and found in good condition.

4:00 pm — First row of wearing plates removed.
Contractor working in No. 2 and No. 3 hot blast valves.
Contractor also loading brick for auxiliary repairs.
Structural contractor lowering material from top of furnace.

8:30 pm — Scaffold lowered to second row of wearing plates.

11:15 pm — Scaffold lowered to third row of wearing plates.

July 9 —
Wearing plates in fourth and fifth row were found in poor condition.

12 - 8 am — Contractor removing tear-out debris from tuyere openings.

7:00 am — Bulkhead put in each bleeder.
Contractor lining hot blast valves and mains.

5:00 pm — Completed removal of wearing plates.
Maintenance men loading scrap wearing plates into car.
Electricians renewing wiring in No. 1 blower's office.

6:00 pm — Contractor lowered scaffold.

9:20 pm — Contractor lowered scaffold again.
Second downcomer opened at top.

July 10 —
Contractor 34 ft below top at midnight.
Gasoline powered shovel being used to dispose of debris.

7:00 am — Contractor began removing inwall cooling plates through hole cut through the shell just above top row of plates.
Maintenance men removed big bell cyclinder and small bell from top.
Minor stove inwall repairs being made by maintenance division.
Contractor repairing hot blast main and hot blast valves.
Inspection of condition of horizontal dustcatcher and downcomer made. Minor repairs required.
Bulkhead placed near top of downcomers so dustcatcher repairs could be made.

11:00 pm — Tear-out to mantle completed.

July 11 —

12 - 8 am — Scaffold raised to top.
Contractor removing debris through tuyere openings.
Contractor working on offtakes to bottom of Y as well as on hot blast main and valves.

8 - 4 pm — Centerpole set.
Old inwall cooling plates being tested in case they should be needed due to delayed deliveries.
Maintenance division replacing distributor and small bell.
Contractor now 4 ft-6 in. below tuyeres cleaning out.

July 12 —

7:00 am — Contractor completed digging out hearth of furnace.

10:00 am — Inspection of carbon hearth.
Carbon hearth looked good and work resumed.

12:00 m — Piers put in bottom — loading and mantle scaffold built.
Structural contractor arranging old wearing plates to salvage good ones.
Contractor stocking brick around furnace.
Hot blast main and valves completed.

July 13 —
Installation of centralized lubrication system started.
Contractor started brickwork on top of top new row of bosh plates which had been carefully tested.
Maintenance division working on bosh coolers, on distributor, and on big bell cylinder.

5:00 pm — Second row of inwall cooling plates started.

July 14 —
Maintenance division closing lower shell opening and working on distributor.
Completed inspection of stoves.
Two stove tops closed.

7:00 am — Contractor has 6-ft scaffold in stack.

3:00 pm — Contractor has 12-ft scaffold in stack.

11:00 pm — Contractor has 18-ft scaffold in stack.

July 15 —
Maintenance division piping inwall cooling plates, set two tub runner sections, and painted trough above mantle.

7:00 am — 24-ft scaffold in stack.

3:00 pm — 30-ft scaffold in stack.

8:30 pm — Bailey thermal valve received in plant.

11:00 pm — 36-ft scaffold in stack.

July 16 —
Maintenance division working on mud gun, setting thermal expansion valve, and placing and packing tuyere coolers.

7:00 am — 42-ft scaffold in stack.

12:00 m — 48-ft scaffold in stack.

1:00 pm — One row of wearing plates.

7:00 pm — Three rows of wearing plates.

July 17 —
Work on centralized lubrication system being completed.
Maintenance division working on coke elevator, setting tuyere connections, and setting Bailey thermal valve.

7:00 am — Four rows of wearing plates.

7:00 pm — Stockline finished.
No. 1 gas washer outlet valve closed, opened mechanical goggle valve on No. 1 boiler house main.
Brought gas to stoves.
Started to heat stoves.
Furnace dome brickwork started.

July 18 —
Maintenance division welding eroded area on big bell, placed tuyere connections and piping, cleaned up cast house area and patched floor.

3:00 pm — Furnace brickwork completed.
Bosh was patched and sprayed.

7:00 pm — Removed centerpole and scaffolding tear-out started.
Top was grouted and top deck segments welded back into place.

July 19 —

Maintenance division completing piping and tuyere connections. Belly pipes and tuyere stocks being installed. Top casting installed.

7:00 am — Started digging hard pan off top of salamander.

3:00 pm — Prepared furnace to dry out.

All top segments welded into position.

Contractor for brickwork loading equipment to move out.

5:00 pm — Blast on to dry out furnace and test cold and hot blast system.

10:50 pm — Blast off.

Preparations made to fill furnace.

Since hearth bottom was still very hot and the bosh area was dry, it was decided to blow in the furnace on a slow schedule and dry out the stack line as the furnace was blowing in. It was the operating department's opinion that drying out the stack lining to a fairly high temperature and chilling it by charging cold damp material might be more detrimental than the procedure followed, since a cold shock would be eliminated.

July 20 —

Structural contractor dismantled the traveling crane boom and arranged to move out.

12:25 am — Charged coke to fill hearth to tuyere level.

Hearth was too hot to use cord wood.

2:15 am — Put 70 to 100-lb bags of charcoal into furnace at tuyere level.

Put up blow pipes.

10:40 am — Furnace filled to 6-ft stock line.

3:50 pm — Furnace lit — blast on.

RECAPITULATION

The daily progress of the tear-out and relining is shown on Figure 3.

The actual time elapsed from blow-out to blast-on was 15 days, 9½ hr. We believe this sets a world's record for a mantle-up relining. A comparison of the actual time shown by the dark blocks on the progress report in Figure 2 and the estimated time shown by the shaded blocks will indicate that one full week was saved through the magnificent effort of the brick contractor.

Although our original planning was for the purpose of expediting the reline as much as possible since it was based primarily on more economical operation rather than complete physical requirements, the various divisions at the plant rapidly quickened the tempo of all work to keep ahead of the advancing schedule each day.

Delivery of last minute items became critical as promised dates had to be advanced several days. One particular shipment was chased all day one Sunday to have it arrive in the plant at 2:00 am Monday morning with castings required at 7:00 am. These castings had to be unloaded, tested, and delivered to job site at the required time so as not to delay the contractor's crews.

Most conditions were found to exist as had been predicted during the January planning meetings. The actual work accomplished should be mentioned in summary for the record.

Brickwork — Contract — The stack was completely relined using approximately 200,000 9-in. equivalent first quality fireclay brick.

Four rows of inwall copper cooling plates were renewed. 10,000 9-in. equivalent firebrick and plastic were used to repair bosh and hearth, gas mains, dustcatchers, hot blast piping, hot blast valves, bustle pipe, tuyere stocks and elbows, and downcomers.

Brickwork — Maintenance — Minor repairs to stove linings and flues outside the scope of the contract work were made by plant bricklayers. The cast house floor was patched and runner linings were repaired as required.

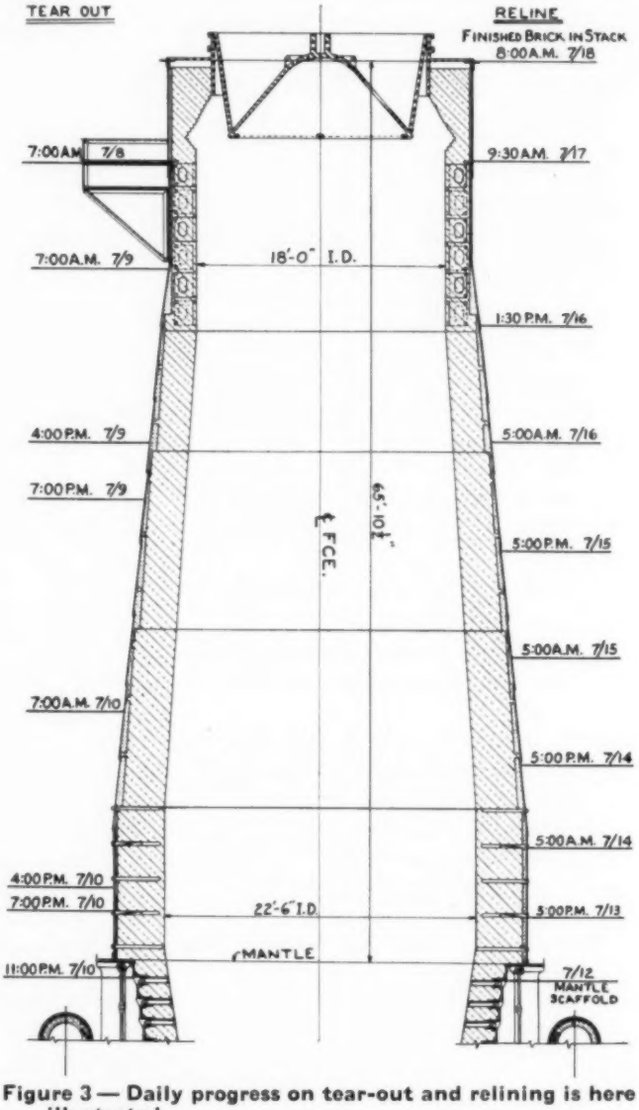

Figure 3 — Daily progress on tear-out and relining is here illustrated.

Major mechanical repairs —

Installed platform below top ring angle.

Reconditioned tuyere stocks for new type blow pipes.

Completely repiped bosh, inwall cooling and hearth.

Repiped stoves, hot blast valves, lines to bell cylinders, cleaned furnace circle pipes. Repiped thermal Bailey valve.

Installed frame for tram pole under big bell.

Replaced all bleeder valve seats, mushrooms and linkages including cables.

Reconditioned furnace walkways — about 20 per cent replacement of floor plates.

Patched plates on downcomers where necessary.

New bolts on skip rails.

Cables and sheaves replaced on gage rods and bell programs.

New packing glands on gage rods.
New small bell, small bell rod and crosshead, new linkages.
Shop reconditioned bell cylinders, large and small.
Rebushed dead eyes and trunnions for bell cylinders.
Large bell seat and hopper patch welded and ground (approximately 30 per cent of seat welded).
Replaced distributor gas seal and rollers and drive shafts.
Installed complete automatic top lubrication system (contract).
New hot blast valves, except tubs — one tub replaced.
New hot blast valve seats.
All new doors, frames on stoves. (Gas doors and observation doors).
Reconditioned air relief valves on stoves by replacement of all parts except body.
Reconditioned mixer valve.
Oil drip in cold blast line.
Stove blowers reconditioned at shop.
Shop reconditioned all motors (17), except skip hoist motors.
Reconditioned limit stops. Made general check and cleaned control boards. Renewed furnace firerod wiring plus additional row (4).
Motor circuit distributor — new.
Stove flue recorder circuit — new.
20 point thermo selector. New 2-in. conduit and wiring.
Hot blast recorder and controller — rewired.
Mud gun circuit — reinsulated.
River pump house —
Changed 30-in. header valve.
Reconditioned and changed impeller No. 4 centrifugal pump (10,000 gpm).
Blowing Room —
1. Changed 12-in. steam header valve No. 2 engine.
2. Hog rod patch between distance piece and guide barrel No. 1 engine.
3. General overhaul of No. 3, 4 and 5 engines.

Replacement of mud gun by reconditioning.
Completely reconditioned larry car trucks and drive mechanism. Doors and door linkage replaced and hoppers relined.
Replaced beaumont birch gates on coke braize system.
New wheels and bearings on skip cars.
Completely refurbished 78-in. thermal Bailey valve at factory.
Section of 78-in. gas main — 33-in. long installed.
Manholes installed in 78-in. dirty gas mains between gas washer and thermal valve.
Seal welding on gas washer shell.
Rewelded furnace deck — 7 holes 2 ft × 4 ft in 1½ in. thick stock.
Seal welded furnace top — general tightening and replacement of bolts on furnace top and distributor.
Coke weigh-hopper scales and larry car scales reconditioned.

SUMMARY

The record performance of this relining shows what can be done by an organization fully coordinated and wholeheartedly cooperating toward a common goal. All individuals from laborers to division superintendents worked with the single purpose in mind of getting the furnace back on the line as soon as possible and each feels the satisfaction of a job well done.

Analyzing the progress report on Figure 2, and more so following the actual progress of the work, it is evident that except for some time being lost during the coke rake-out due to its "frozen" condition, it would be physically difficult to improve the performance of 15 days, 9½ hours.

DISCUSSION

PRESENTED BY

E. K. MILLER, Superintendent Blast Furnaces, United States Steel Corp., Gary, Ind.

J. W. COX, Assistant to General Superintendent, American Steel and Wire Div., United States Steel Corp., Donora, Pa.

C. W. PHILLIPS, Chief Engineer, Woodward Iron Co., Woodward, Ala.

BRUNO VEZZANI, Works Engineer, Donora Steel and Wire Works, American Steel and Wire Div., United States Steel Corp., Donora, Pa.

E. K. Miller, Jr.: The rapid mantle-up relining accomplished at Donora in 15 days 9½ hr from blast off to blast on stands as a fine example of what can be done by precise planning, and close cooperation. This record on an all-out attempt to get a furnace off and on as quickly as possible will be very difficult to improve upon.

It is perhaps of interest to discuss briefly alternate methods of accomplishing two phases of the described job, which have been in practice at Gary Steel Works.

1. In cleaning out a furnace blown out by the small coke method, our practice has been to wash out the coke immediately, while still hot. By doing so, the time required to quench the hot coke is eliminated. This is accomplished with the large bell closed, bleeders open, and with an abundant flow of steam maintained in the dust catcher, and in the top of the furnace. If the top temperature starts to rise above desirable limits, the steam to the furnace top is turned off, and water sprays turned on. There are sprays in each quadrant of the top, which are drilled and set so the sprays are directed across the furnace. In this way it is thought the water flashes off into steam quickly, absorbing heat, and preventing localized water accumulations. As a safety precaution, however, the men are ordered away from the furnace, while the water sprays are on. When the top temperatures are returned to the control range, the water is turned off, the steam turned on, and the wash out job resumed. This method has been successfully used for many years.

2. After the coke has been washed out as far as practicable, a section of the tuyere jacket and a section of the bosh bands are removed to provide an area large enough to accommodate a bucket tractor (bracing is required to prevent remaining members from springing). The brick wall thus exposed is blasted out to permit the tractor to operate in and out of the furnace to effect quick removal of the brick torn down from the stack and the remaining stock. After the furnace is cleaned out, this large opening permits efficient handling of scaffolding and relining materials. When the

brick work in the stack is well under way, the tuyere jacket section and bosh band sections can be reset, and the wall keyed in and rebuilt. The aim during a rush job would be to finish this brick work at the same time the top brick work is completed.

These points are brought out only to stimulate thoughts on alternate methods of attaining the same end, as it is realized that each plant has its own individual types of conditions to meet. Mr. Vezzani's paper sums up what appears to be a most excellent piece of work.

J. W. Cox: As far as the relining is concerned, all I can do is repeat what has been said before. Basically, it is a very good example of what can be done by cooperation.

This record is an example of the American way of doing a job. We had a lot of cooperation and help from many people, both inside and outside of our own organization.

Prior to our first planning meetings, William Holman, who operates the furnaces at Wheeling Steel, graciously asked us down to look at the job he was doing. The furnace which we inspected was eventually lined in 18 days and the visitation was very helpful to us in planning our schedule.

Fortunately for us, the same contractor and superintendent who were relining the blast furnace at Wheeling Steel were awarded the brick contract at Donora. Consequently, we could pre-plan our work very easily.

A job like this one is completed successfully when everyone pulls together as a team. Our American Steel & Wire Division Cleveland engineering group; Philip J. Gow, our division master mechanic; Bruno Vezzani, works engineer; all had an important part and did an excellent job during the relining.

The method at Gary is an excellent method and had we used it we might have been able to save 6 or 8 hours.

C. W. Phillips: I have a two-pronged question. First, Mr. Vezzani, how do you center that pole? How do you know when you are on the center of the furnace?

Bruno Vezzani: We had our field engineer center the big bell. First, the big bell was cabled up tight, then we dropped the plumb line down through the center of the furnace and so centered the tram pole. Does that answer your question.

C. W. Phillips: In other words, you centered the bell and hopper where it was — there was no change. Suppose your furnace were tilted?

Bruno Vezzani: Fortunately, in this case, it was not necessary to decide whether to follow the slope of the furnace or cut brick because the center of the big bell was as close to the center of the hearth as we could possibly have hoped.

C. W. Phillips: Obviously the big saving of time was in tearing out your brick lining, was there anything special, anything new, any special method used in that three days of work that you did? I think in your preliminary schedule you estimated six, did you not?

Bruno Vezzani: There was nothing special in it except the contractor had a group of men working who did an excellent job under very trying conditions.

J. W. Cox: There is one thing that might be mentioned. For a week prior to the reline, we ran the furnace very lean. We were fortunate that there were no big scabs on the brick. No difficulties or delays were encountered while digging out the old lining.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

No Meeting.

BUFFALO SECTION

Tuesday, June 7, 1955, Fourth Annual Golf Meet.
Cherry Hill Country Club, Canada.

CHICAGO SECTION

Tuesday, June 7, 1955, Golf Tournament.
Gary Country Club, Gary, Ind.

CLEVELAND SECTION

No Meeting.

DETROIT SECTION

No Meeting.

LOS ANGELES SECTION

No Meeting.

PHILADELPHIA SECTION

No Meeting.

PITTSBURGH SECTION

Monday, June 27, 1955, Golf Party.
Fox Chapel Golf Club, Fox Chapel, Pa.

SAN FRANCISCO SECTION

No Meeting.

ST. LOUIS SECTION

Wednesday, June 29, 1955

"Eddy Current Drives," by Ray Dirksen, Dynamatics Corp.

Skaggs Restaurant, Wood River, Ill.

YOUNGSTOWN SECTION

Wednesday, June 15, 1955, Golf Party.
Youngstown Country Club, Youngstown, Ohio.

SCREWDOWN LUBRICATION

. . . . screwdown lubrication has been improved through the use of lead naphthenate lubricants . . . . their use has also reduced temperatures for both steel and bronze nuts . . . . tonnages have also been increased markedly . . . .

By WILLIAM A. HOLT
Eastern District Engineer
The Brooks Oil Co.
Pittsburgh, Pa.

▲ DURING the period of the last half century or more, the steel industry has been one of phenomenal progress and rapid expansion with constant improvement of rolling equipment. With the advent of the modern continuous strip mills about twenty years ago, the pace was intensified and more severe maintainance and lubrication problems developed. Blooming and slabbing mills have been prominent in these developments entailing problems in lubrication for satisfactory, efficient and economical results. In the latter phase, the subject of screwdown screw and nut lubrication can never be overlooked as one for free discussion.

The lubrication of screwdown nuts and screws is usually one of the most difficult of all problems. As a guide to the problems involved in modern mills, it might be advisable to review the changes that have occurred in the past fifty years. Early in 1900, many blooming mills still used racks and pinions on the screwdown drives. The major problem was not a matter of lubricating the racks and pinions, but the hydraulic maintenance and packing. Next came motor driven screws. The first installations were, by today's standards, very slow. Screw speeds were in the neighborhood of 160 in. per min and were driven by series or compound motors. The nuts were of lead bronze and the lubricant on both nuts and screws was usually black oil. Even at these speeds, the screws would stick and it would be necessary to use white lead and engine oil to, in mill vernacular, give them a physic to loosen the screws. The first efforts made to increase speeds were by increasing motor sizes and later through adjustable voltage controls. Even these slight speed increases developed problems of screw and nut material as well as lubrication. The original lead bronze nuts were gradually supplanted by phosphorous bronze, manganese bronze, tool steel and other high tensile materials; the screws from carbon steel to heat treated, nitrided, flame and case hardened steels, and other wear resisting materials. The progress in lubrication was from black oil to engine oil, compounded cylinder oil and then to leaded and other high film strength compounded products. The application of lubricants was improved from hand to controlled automatic systems, all in an effort to increase the service life of screws and nuts. Modern screwdowns did not really appear in the picture until the event of the high speed strip mills.

With the modern strip mill came what is known as the high lift blooming and slabbing mills. Thus speeds for the edging passes became paramount. The series motors were replaced with shunt motors having magnetic contactors with variable voltage drives and laminated generators. Speeds of 650 in. per min and upward are obtained with maximum rate of acceleration and deceleration.

Lubricants for modern screwdowns must have outstanding characteristics to meet the tremendous pressure of the threads, high speed travel, maximum rate of acceleration and deceleration, variable temperatures, steam vapors, water, metallic mill contamination, and be equally efficient on screws, worms, bevel and spur gears.

The lubricant must possess high film strength, good adhesiveness, low pour point, excellent wetting characteristics and be non-corrosive.

Viscosity is most important in that the film thickness must take the rubbing action and shock loads of the screw without film breakdown and yet should flow slowly to prevent waste or excessive consumption. Fluids have the advantage of ease of application, washing action of flow in travel down the screw, and an excellent lubricant for the drive units without fillers which could cause screw drag. This type is also for lubrication of gears and bearings in addition to screws.

Methods of application require care and provisions for the entrance of the lubricant into the threads. This

may be provided in two ways. By cutting a slot in the screw threads parallel to the axis of the screw, ½ to 1-in. wide and about ⅛ in. in depth below the root of the thread. This slot should not extend the entire length of the screw, but should extend about three-quarters of the length into the nut when the screw is at its maximum travel into the nut. The downward flow in the threads will provide sufficient lubricant for the lower half of the nut and breaker block.

Another method is to drill two holes in the nut paralell to the axis of the screw and provide two to four holes at right angles and into the root or bottom of the thread. The holes are usually drilled from the bottom upward, in some cases being large enough for insertion of a pipe with welded nipples for flow into the right angle holes. This permits ease of cleaning or adjustment by regulation in orifice for distribution of lubricant, the major quantity being required towards the top of the nut. This method is essential with worm drive or other methods where lubricant cannot flow down the screw into the nut.

With bevel gear drives, the lubricants are applied to the mesh of the gears with enough overflow for gradual flow of lubricant down the screw into the top of the nut. The lubricant should be measured and applied by either automatic or drip method for the most efficient results and consumption. In this method the flow of lubricant into the nut is by gravity.

With worn or spline drive screws, the drive is usually encased in a sealed housing and provision is made for continuous flow from an automatic system with provisions made for the excess to flow back into the system. Variable results have been obtained with this method and it is the opinion that best results are accomplished by intermittent automatic applications of small measured amounts in the interest of economy.

Prior to the advent of the high lift, high speed type mills, most of the screwdowns were lubricated with either black oil or compounded cylinder oil, but nut life was short and consumption of lubricants excessive. Various experiments were tried and one of the most informative was conducted in one of the major eastern mills. This mill was lubricated with black oil on the drive gears and compounded cylinder oil on the screws. Experiments with various compounds determined that by using extreme pressure lead naphthenate lubricants it was possible to immediately reduce the nut temperatures about 25 F, and a lubricant consumption reduction from eight gallons per screw per turn to approximately one gallon per screw per turn was achieved. This verified other experiments conducted by the old empirical formulae. One blooming mill in Western Pennsylvania rolling squares and other shapes, increased nut life from 500,000 tons to an average of 1,500,000 tons by changing from compounded cylinder oil to a lead naphthenate compound. A slab mill in same district increased nut life from about 2,000,000 to some yet undetermined tonnage as the nuts are still in service and have produced over 6,000,000 tons. Similar results are obtained on other units and a conservative statement is made that practically all of the new high lift mills now operate with lead naphthenate compounds.

As pointed out earlier, viscosity is most important. Most of the high speed mills have found 250 SSU at 210 F viscosity to be logical in summer and acceptable in winter, but 160 SSU at 210 F viscosity is used by quite a few mills in winter, especially where operations are intermittent and subject to a wide range in ambient temperatures.

Lead naphthenate compounds provide high film strength, adhesiveness, good wetting action, negative corrosion characteristics, low pour points, and are water repellent. These have been accepted for twenty years and accomplishments for this difficult problem have been widely recognized.

Protection boots should be provided over the exposed section of the screw threads to prevent mill metallic contamination and water insofar as possible from coming in direct contact with the screws. These do not have to be elaborate. Boots can be metallic type or made of asbestos cloth. A ring should be provided at the top so that boots can be anchored to the mill housings and a similar ring at the bottom for anchoring to the top roll carrier. For inspection purposes, provisions should be made so that the bottom ring can be suspended from the top of the housing for screw inspection. A spring about 4 in. larger in diameter than the screw should be used to keep the boots from collapsing. Some mill operators are of the definite opinion that the application of boots increase the life of the nut as much as 25 per cent.

While various methods of application and refinements in material are contributing factors to longer nut life, correct lubricants which will provide high film strength, flow slowly, have good wetting action, firmly adhere to metal, are non-corrosive and water repellent, are the best known corrective measures which can be used in this type of service.

DISCUSSION

PRESENTED BY

A. E. CICHELLI, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

JAMES L. DUCHENE, National Bearing Div., American Brake Shoe Co., Pittsburgh, Pa.

CHARLES E. HOMER, Superintendent — Maintenance and Power, Youngstown Sheet and Tube Co., East Chicago, Ind.

CHARLES R. HAND, Assistant Superintendent Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

A. E. Cichelli: The author deserves commendation for the amount of background and information he has been able to insert in a short paper. When the subject of screwdowns is brought up among lubrication engineers, I believe you will find one unanimous feeling among them. They would prefer to be able to hermetically seal them and circulate the lubricant within. Next to that they will settle for boots over the screws, an automatic system to all points, and recirculation within the screwdown drive.

There are several considerations that I would like to bring up. First is the fact that the screwdown drive, the bushings and guides for the screw, thrust surfaces,

and the breaker block are just as important as the screw and nut themselves. Wear on these parts has a direct bearing on screw and nut life. Therefore, careful attention must be paid to path of the lubricant from the drive down through to the nut. Later designs on high-speed screws supply oil to the worm or bevel-gear drive and bearings from a supply pump. It has been found by simultaneously maintaining a predetermined level in the gear case that an intermittent feed of about 6 min is adequate. Some oil works its way from the screw top, which is supplied separately, down along the flats, splines or keyway until it reaches the thread. From there it finds its way down to the nut and eventually to the breaker block. For added insurance, supplementary feeds are directed to the guide bushing, to the thrust collar under the big gear, to the nut itself and in some cases to the breaker block.

Abnormal screw and nut wear is not always due to inadequate lubrication. We have found improper mill balance to be a serious factor, materially increasing the load on the threads. Incidentally, we have found it to be a fallacy to evaluate lubrication by comparing tonnage between two similar mills. For example, our best performance occurred at a plant where they wait until the nut thread is worn to ¼ in. thickness while other plants change theirs at ⅜ in.

We agree that lead naphthenate lubricants have improved performance and reduced temperatures on both steel nuts and bronze nuts. One instance of lime soap grease on the nut has done well, also.

Because of improved performance with automatic lubrication, all of our blooming mills have been so equipped. Screwdowns on strip mills, however, have been successfully lubricated by gravity flow alone and according to our experience automatic systems have not been necessary.

J. L. Duchene: The paper mentioned a blooming mill in the Pennsylvania district that increased tonnages from 500,000 to 1,500,000, and a slabbing mill that had increased tonnages from 2,000,000 to currently 6,000,000 tons rolled. Were the hardness, the surface finish and the material in the screw, as well as the surface finish, the hardness, and the alloy in the nut, the same in both cases?

William A. Holt: To the best of my knowledge, they were.

J. L. Duchene: I was just trying to establish that the complete gain was due to the lubrication rather than something else.

Charles E. Homer: There has been a great deal of discussion here about the type of lubricant used on screwdown nuts. In my opinion, something equally important is the manner in which the lubricant is applied. Various mill manufacturers and screwdown users have tried many different ways of applying this lubricant, and there are a great many variations that are equally satisfactory.

In our plant we tried slotting the nut the entire length and drilled holes to feed the lubricant through this slot. This particular method was very unsatisfactory as it allowed the lubricant to work down and get out of the nut proper, without doing the job for which it was intended.

We are now applying the lubricant from each side of the screwdown nut through several holes drilled into the threads. This apparently is doing a very satisfactory job.

Charles R. Hand: I think one of the biggest factors in being able to run mill screws and nuts for the long periods we are now able to run them, has been the development of a satisfactory boot to go around the screws.

If we are obliged to use a heavy lubricant, or, as the speaker put it, a slow-moving lubricant, to come down between the threads and the nut, then when it gets out of the nut it also moves very slowly until it gets to the breaker block. Previous to the time we protected our screws with boots, the quality and the kind of lubrication was secondary to the "quality" and "kind" of abrasive material that adhered to the lubricant on the exposed section of the screw.

Certainly, as Mr. Cichelli pointed out, the hydraulic balancer is a large contributor. It is not good practice to carry more weight on the accumulator to balance the rolls than absolutely necessary, and the closer this balance is, the less load there is on the screw when it is going up or coming down.

WANTED!

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THE RUST ENGINEERING COMPANY . . . CELEBRATING ITS GOLDEN ANNIVERSARY

INDUCTION HEATING OF INGOTS PROVED PRACTICAL FOR ROLLING

By M. C. D. HOBBS
General Superintendent
Western Canada Steel, Ltd.
Vancouver, Canada

▲ FOR what is believed to be the first time anywhere, ingots are now being heated on a production basis by electric induction at the Vancouver Rolling Mills plant of Western Canada Steel, Ltd. in Vancouver, Canada. Using available figures of comparative costs of operation of rotary hearth furnaces, pusher furnaces and batch-type furnaces, the new dual frequency, twin-tube induction furnace shows considerable savings over all conventional heating methods. In addition, although no de-scaling equipment is used, the rolled products are clean in appearance, and free from scale.

Established in 1948, Western Canada Steel Ltd. operates three subsidiary companies, Pacific Bolt Manufacturing Co. Ltd. (founded in 1924, and the original company of the group), Vancouver Steel Co. Ltd., producing ingots from scrap, and Vancouver Rolling Mills Ltd., rolling merchant bars, reinforcing bars and light structural sections.

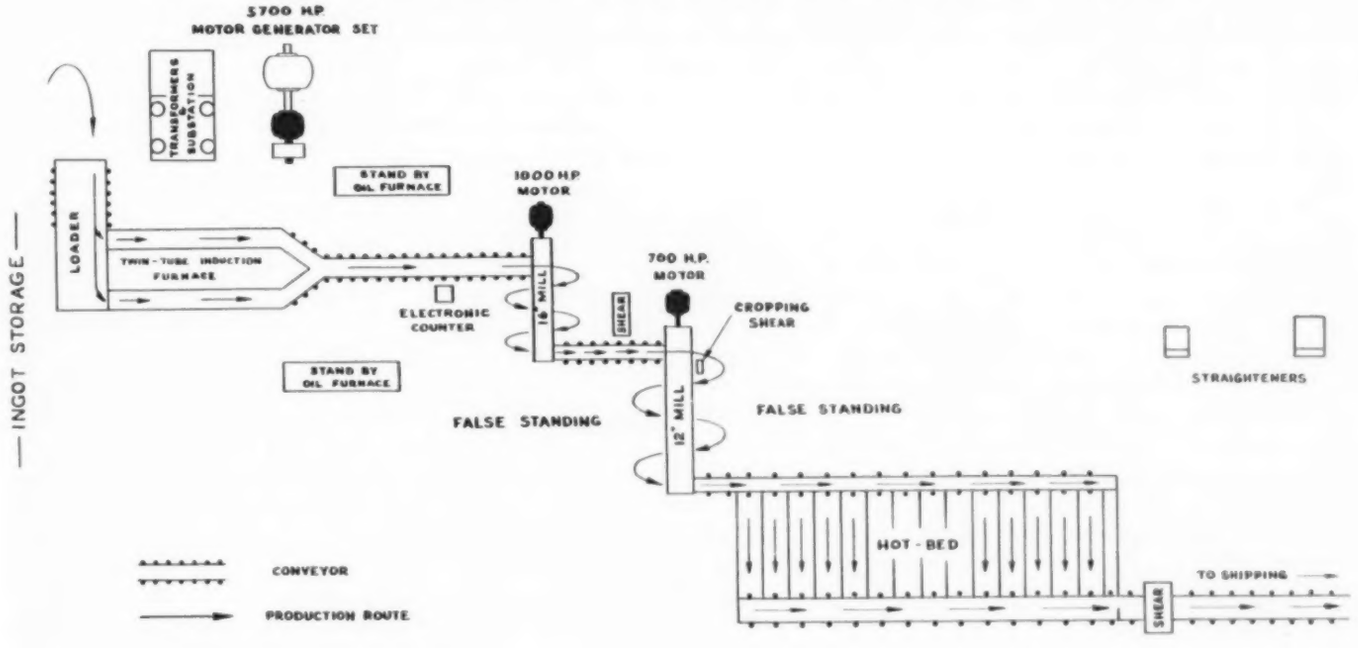
Western Canada Steel's melting and finishing capacity grew with increased technical efficiency, until, by 1953, the heating capacity at Vancouver Rolling Mills was seriously curtailing production. The engineering staff of Western Canada Steel Ltd. investigated all known practical methods of ingot heating, and felt that further development of induction heating applied to a cast structure, or ingot, might hold promise of increased efficiency over conventional methods of heating.

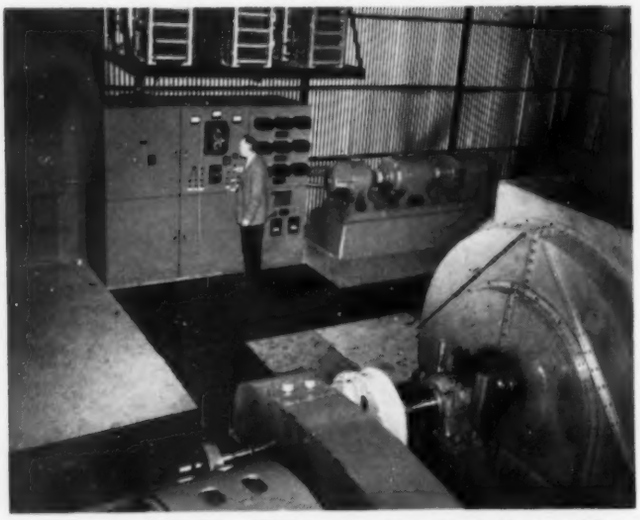
Factors influencing this decision were the low operating costs of the dual frequency induction furnace, and the promise of high quality finished products, despite the high capital investment. (This installation ran to a cost of slightly over $500,000).

Another attractive feature, which carried considerable weight in making the decision to swing to induction heating, was the possibility of reducing normal scale loss experienced in standard type furnaces (which lies between 3 and 5 per cent.) It was calculated that this alone would yield a value of 80¢ per ton per 1 per cent decrease. In practice, an average scale loss of less than 2 per cent has been realized.

By contrast with the rotary or pusher type furnaces, the induction furnace can handle a wide range of ingot sections and lengths, and contains no more than eight tons of ingots at any one time. This was of prime importance in retaining a flexible merchant mill operation.

Figure 1 — Diagram shows production flow at Vancouver Rolling Mills Ltd., Vancouver, Canada.





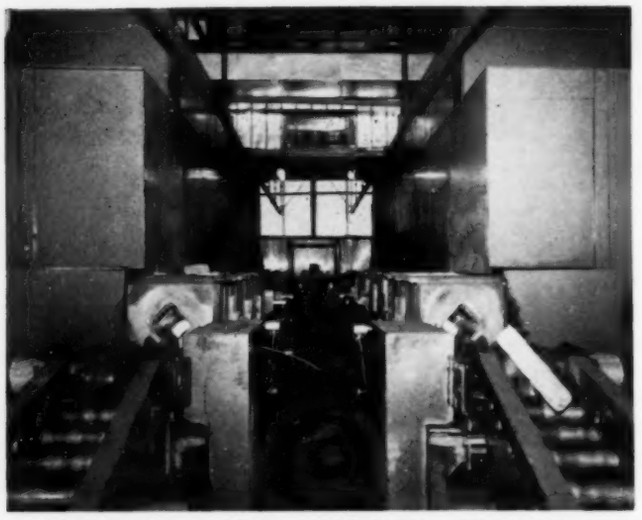


Figure 2 (left) — The 5700-hp, motor-generator at Vancouver Rolling Mills, Vancouver, Canada, steps up frequency of electrical current to 600 cycles to produce heat in ingot by means of the twin tube induction heating unit. Figure 3 (right) — Electrical power at 60,000 v provides the 10,000-hp energy for this twin tube electrical induction heating unit at Western Canada Steel's Vancouver Rolling Mills.

The actual heating takes place inside a tube, or coil tunnel, through which the ingots are pushed in a continuous stream end to end. Since the heat is generated within the ingot, it is possible to keep the furnace structure, including the outside surface of this tunnel, quite cool.

To keep the overall length of the unit down, it was designed with two identical parallel tunnels. This arrangement also provides some increase in flexibility, since either side may be operated independently. Simple, rugged construction was used throughout, to facilitate maintenance and to ensure uninterrupted operation.

Fork lift trucks are used to bring the ingots from stock piles in the yard, and to place them on a table fitted with "walking beams." These spread out the bundles of ingots and advance them to another table fitted with flat rubber conveyor belts which carry the ingots forward to the feeders.

More automatic handling equipment carries these ingots from this point and deposits them as required, one at a time, in the feed trough. Hydraulic rams push the ingots from the feed troughs into the heating tunnel. The line of ingots is continuous, so that, as one ingot is being pushed into the feed end, a hot ingot is emerging from the discharge end. Interlocks keep the two lines in step, so that ingots are fed to the mill at regular intervals.

An operator's 'pulpit' is arranged above the two lines, so that he has a good view of both ends of the furnace, and also a clear view of the mills. The control panel includes radiation pyrometers for indicating the temperature of the steel, situated at the end of the 60-cycle section, the center of the 540-cycle section, and at the discharge point.

The operator also has control of the feed and power input, as well as on/off controls for all parts of the installation. In addition, he has control of a power driven roller conveyor, which extends from the furnace to the mill, and a gate provided in this conveyor, which allows him to direct ingots to the mill, or to set them aside. Meters indicate current, voltages and power in the various circuits.

Approximately half of the power used is applied to the heating line at the standard frequency of 60 cycles. To achieve the best efficiency, the balance is converted to a higher frequency in a generator driven by a 5000-kva synchronous motor.

The furnishing of power to the induction heating furnace presented a major problem. It was necessary to hold the cost of supplying power to the unit to a minimum consistent with reliability and safety. It was realized that, being the first unit of its kind, original estimates of power requirements might have to be corrected from experience. A number of quite unusual problems were posed.

Basically, 7,000 kw of energy was required; half being at 540 cycles and half at 60 cycles. The 540-cycle energy was to be supplied at 400 volts, and 550 volts was the selected voltage for the 60-cycle supply.

It was decided to purchase a 3,500-kw unity power factor, 720-rpm, 540-cycle alternator, and to drive this by a 5,000-kva synchronous motor, which was available and designed for the same speed, 720 rpm. This provided the opportunity for power factor correction of the remainder of the rolling mill induction motor load. The motor voltage was 4,000.

Power had to be secured from the 60-kv system of the power company, which necessitated running a new line from the 60-kv ring bus to three 3,000-kva water-cooled transformers for stepping down from 60 to 4-kv. The 60-cycle supply was obtained from a 4,000-kva, 3-phase transformer with off-load tap changing and stepping down to 550 volts.

It was decided to start the 5,000-kva motor driving the 540-cycle generator by means of an auxiliary slip ring motor, and to synchronize this with an automatic synchronizer by push button control. An air clutch disconnected the slip ring motor after synchronization was completed.

The bussing of the 540-cycle current presented a difficult problem, and was finally accomplished by means of a large number of individual cables with phasing interleaved, and supported by wooden clamps, in an aluminum race-way. No switching was done on the 540-cycle supply, and protection was obtained by over current relays and balanced split phase protection of the generator windings. The auxiliary controls

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from these relays operated the contactor type field discharge switch controlling the excitation to the 540-cycle alternator.

The 540-cycle induction heating coils were divided into two groups of each phase, and the main cabling from the generator was split to feed each grouping of induction heating coils.

Individual ammeters were provided to register the current to each coil group, and ammeters were also installed to register the total generator current output on each phase.

The generator was star connected, and this was solidly grounded and the return lead from each coil was also connected to this ground.

The 60-cycle power was controlled by six circuit breakers similarly feeding two groups of induction coils in each phase. The 4,000-kva transformer supplying this energy was star connected, and the returns from each coil were connected to the star point, which was also grounded.

An investigation into the ground conditions indicated that a ground mat with sixteen eight-ft rods spaced approximately 8 ft apart would give a ground resistance of approximately a half ohm. This ground mat was built, and its resistance was found to be almost exactly the anticipated value.

Power factor correction of the induction heating coils was, of course, a major element of the installation, and capacitors were connected in groups to each coil group of both frequencies.

The correction required varies in the different coil groups with the temperature of the billets passing through the heating coils. Initially the inductance was higher at the cold section of the furnace, and adjustments were made from experience to secure the optimum power factor conditions. The capacitors for the 540-cycle coils were water-cooled, and those for the 60-cycle coils are not cooled.

The average power factor throughout is better than 90 per cent, and approaches unity under most conditions. It is, however, subject to variations depending upon the sizes of ingots fed through the coils.

In order to control the heat input to the high frequency coils, a motor operated field rheostat permits the variation of the 540-cycle alternator voltage.

Input power is measured by watt meters and watt-hour meters, and these have established a power consumption of the largest ingots of 300-kwhr a ton, or better, including all losses. The rate of flow of the larger ingots varies from twenty to twenty-five tons per hour. With smaller ingots, the average consumption is higher, and the rate of flow somewhat less.

One of the most striking features of the new operation is its speed. The total heating time ranges from 3.6 minutes for the smallest ingots to 8.4 minutes for the largest. Tabulated below are the most common ingot sizes heated, their typical cross-section, length of heating time and tons-per-hour-output:

Wt, lb	Size, in.	Tons/hr output	Time, min
112	4 x4 x36	15	3.6
146	4 x4 x42	15	4.25
240	5½x5½x43	20	4.75
265	5½x5½x45	20	5.0
365	5½x5½x56	20	5.50
466	6¼x6¼x49	20	8.4

These ingot sizes permitted the use of 60-cycle power directly on the induction heating coils for all ingots, up to the curie point, but a higher frequency was required for heating the smaller sizes from this point to the final temperature required for rolling.

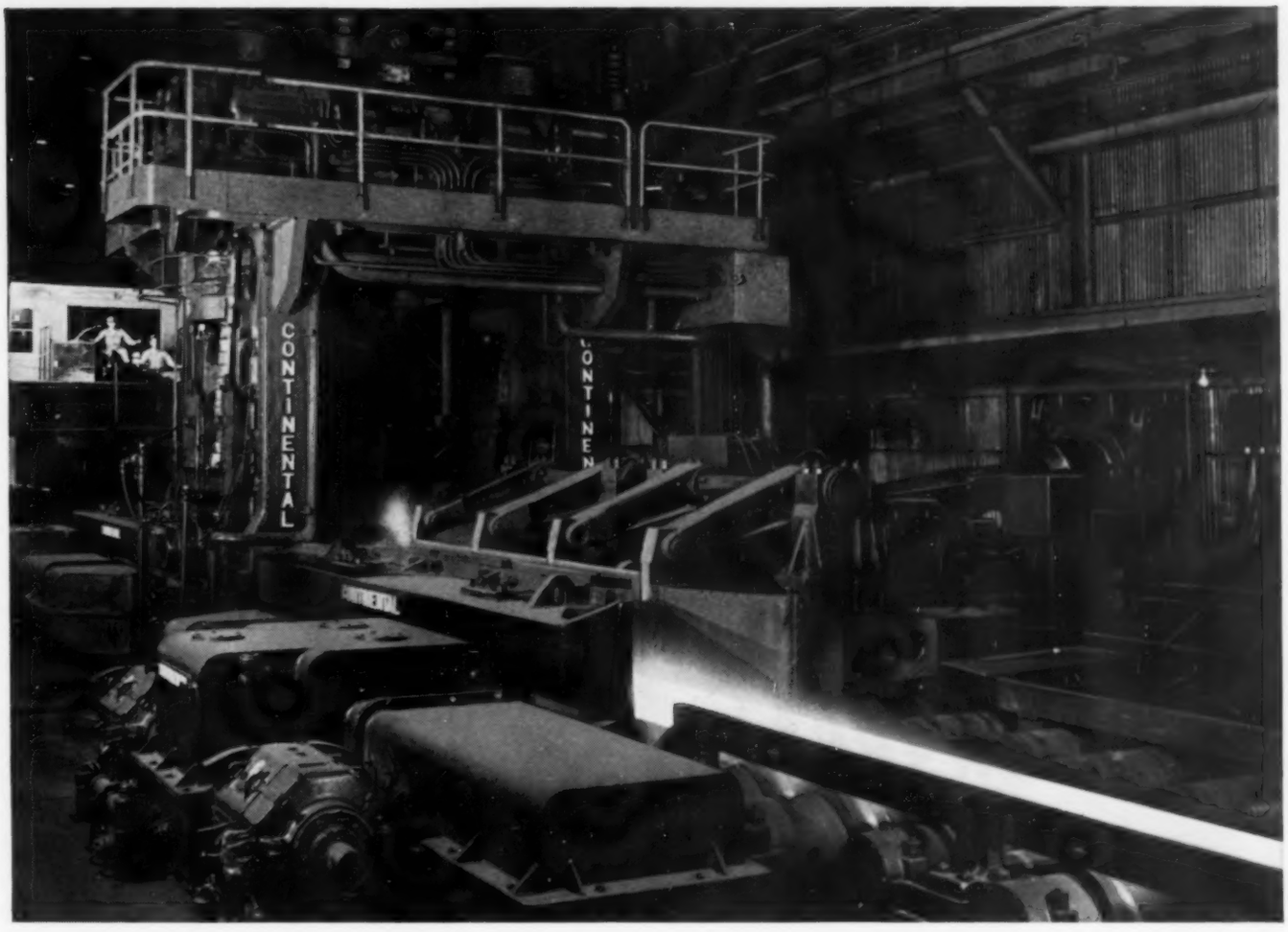
Something less than ten minutes elapses from the time a cold ingot enters the plant until it is a finished bar on the hot bed. Thus there is a relatively small tonnage of material in process at any time, and the furnace may be started or stopped practically at the touch of a button.

The furnace operates with a total number of four men per shift, and higher production rates than presently achieved will not require an increase. The furnace crews' working conditions have improved immeasurably. They are at no time subjected to heat, and can work in perfect safety and comfort throughout the operation.

The problems encountered in putting this unit into operation were not out of proportion, considering its size and uniqueness. Because of its size, any testing prior to the completion of the installation was necessarily limited. Heating tests were limited to a single ingot, and it was quite impossible to duplicate operating conditions, even approximately.

It was found that the high frequency generator was able to operate at substantially in excess of 400 volts, provided the power factor was maintained at a proper level. It turned out to be desirable to operate at the higher voltage, and temperature rise has not limited the current out-

Figure 4 — The 16-in. mill at Vancouver Rolling Mills is powered by a 1000-hp motor.



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in this "dual-duty" Continental Mill

Experienced steel men can see at a glance that this big bruiser is a 40-inch blooming and slabbing mill—and a beauty. But that's only *half* the story!

It was originally intended for intermediate rolling of blooms and slabs for further rolling in the continuous billet mill. But when it was pressed into service from necessity, it did a whale of a job of rolling from ingots to slabs in the hot strip mill!

That's why we're extra-proud of the performance of the 235 Hyatt Roller Bearings in main tables, furnace tables, feed rollers, auxiliary rollers and lineshafts of this versatile mill. Here's proof again that in the long run, the *best* bearings you can buy are the most economical—HYATTS!

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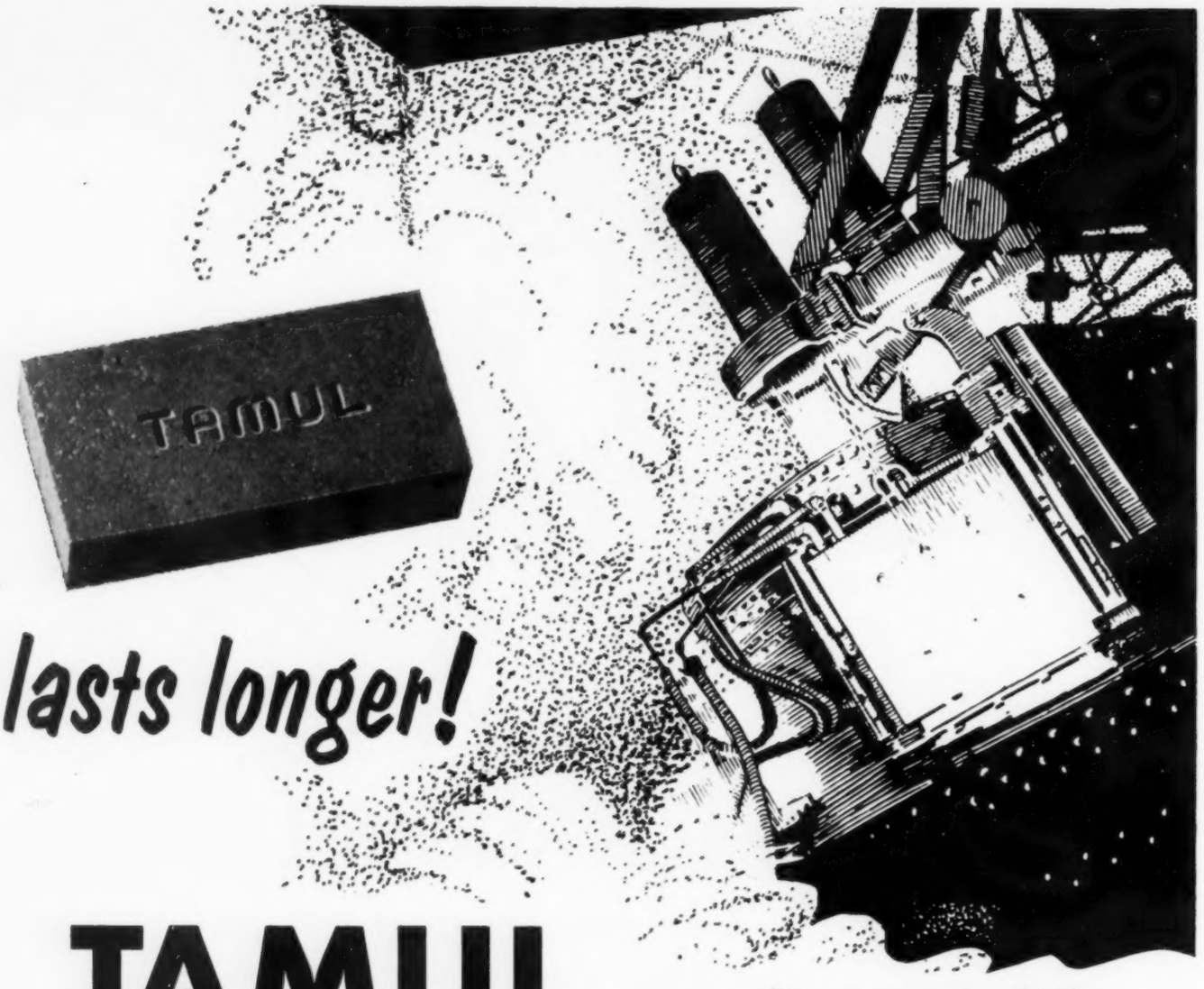

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TAMUL prolongs life of direct arc roofs

TAMUL (Taylor synthetic mullite) brick and special shapes do an outstanding job of increasing roof life in direct arc electric steel melting furnaces.

Complete TAMUL roofs, and roofs "balanced" with TAMUL in the critical areas, are proving economical in furnaces ranging in size from the smallest to the largest now in use. In Michigan, an operator of a 6-ton furnace melting steel reports that his TAMUL roof gives *four times* longer service life than that obtained with silica brick.

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put, so that the 540-cycle alternator actually has a considerable excess capacity above its rating.

The major operating problem arose from the fact that this was a pioneer application. Since it was new, there was no bank of previous experience upon which to draw, and while ultimately the operation and maintenance was reduced to simple, straightforward routine, this had to be developed in actual production. Consequently, all the expected benefits from the new furnace were not realized immediately. However, production was maintained on the new unit from the start, with increasing efficiency as the crew became more experienced.

The coils presented the most serious maintenance problem. They are insulated with glass tape and silicon varnish, and cast in a castable refractory of high density and strength. This cast housing prevents the vibration of the coil from breaking down its insulation.

In the beginning the coils were constructed with 310 stainless steel liners. The insulation packed between the coil and the liner broke down after 8 to 9 shifts of operation. It was found that the severe vibration of the ingot resulted in the liner abrading the insulation, until a short between turns occurred. These stainless liners have in the main been discarded, and replaced with high silicon ceramic liners, this liner being bonded to the coil and held immobile by the castable refractory.

Cooling water was necessary for the 60-cycle and 540-cycle coils, the capacitors, 3,000-kva transformers and 540-cycle alternator. This water was supplied from a cooling tower of the multi-baffle type, providing water at 60 degrees centigrade at a rate of 500 U.S. gpm, at 70 lb per sq in. pressure.

The Unit was built by General Engineering Co. Ltd., Toronto. Design commenced in November 1953, and the unit went into full production the following July. By March of 1955 (8 months later) it had heated over 30,000 tons of ingots.

Only 75 per cent of the furnaces' ultimate productive capacity has been realized to date. Further development during 1955 will yield increased production and additional savings in heating costs.

The application of induction heating of billet-sized ingots is now proven practical, and where plentiful power is available and reasonable, reductions in the cost of heating can be achieved without sacrificing flexibility.

PLANNED Maintenance is PRODUCTIVE Maintenance

By S. J. BARTOS

Maintenance Foreman, Refractories Div., The Carborundum Co., Perth Amboy, N. J.

▲ PLANNED maintenance is productive maintenance when the right plan is turned into a controlled program employing the right testing devices and adequate records. The refractories division plant of The Carborundum Company is a case in point of the many benefits achieved in a switchover from ordinary maintenance operations to an over-all productive maintenance program covering the management and care of all buildings and equipment used in the manufacturing operations. That applies for everything relating to production—from the initial handling of the raw materials, through the crushing, mixing, forming and firing operations in the fabricating of super refractories, to operation of the huge dust collector system upon which we rely heavily for the continuing efficiency of plant personnel.

There are actually three main factors or phases in the transition we are now making from earlier concepts of plant and equipment maintenance to our new view of the whole plan and program as an integral element of production.

Three Major Steps — Step 1, recently accomplished, is our switchover to fully modern electrical power distribution.

Step 2, is the introduction of new "testing dimensions" to insure there is a minimum of downtime on our power flow and power utilizing production units. We do not wait for something to happen; every motor and every electrical safety device is now subject to on-the-job operating condition tests, under carefully planned schedules designed to insure the maximum of prevention and a minimum of conflict with production schedules.

Step 3, is the introduction and planned extension of a simplified visible card system of control records for easy clerical upkeep and at-a-glance management review. Designed primarily and used here initially

(*Please turn to page 132*)

"Our Welding Machines were repeatedly being shutdown . . *until we changed to Fusetron Fuses*"

"They eliminated production losses due to needless fuse blows."

"Our service shop is headquarters for the Detroit area of Fruehauf's operation. Trucks, tractors and trailers come in for repairs.

"As you know, motor carriers don't make money if they aren't hauling freight. It's our job to have the equipment rolling — and fast!

"But we were having trouble with shutdowns. Ordinary 60 ampere fuses were constantly blowing on our welding machines. We have 12 of these machines — that can be connected to 60 ampere switches located throughout the shop.

"Since many major repair jobs require welding, these shutdowns were really a serious problem for us.

"In an effort to avoid these shutdowns, we installed Fusetron fuses. Since changing, there hasn't been any needless fuse blowing on the welders. Fusetron fuses completely eliminated the trouble."

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Fusetron Fuses Offer Maximum Safety

The 100,000 amp. interrupting rating of Fusetron fuses is apace with the high capacities of today's network systems — and they are adequately safe to meet future circuit growth.

Fusetron fuses reduce the expense of damaged equipment and the danger of fire and other hazards that can result from electrical faults because — they protect against short-circuits, harmful overloads and single phasing.

To Production Engineers
Fusetron Fuses Offer Increased Production

Down-time is reduced, because Fusetron fuses wipe out needless blows caused by harmless overloads or excessive heating of panels or switches.

HERE'S WHY FUSETRON FUSES GIVE ALL-PURPOSE PROTECTION

A fuse link combined with a thermal cutout — the result, a fuse with tremendous time-lag and much less electrical resistance and an interrupting rating in excess of 100,000 amps.

They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to same dimensions as ordinary fuses, FUSETRON Fuses fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 ampere, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

Write for bulletin FIS.

To Maintenance Engineers
Fusetron Fuses Offer Savings in Time and Work

Once properly installed, Fusetron fuses require no periodic inspection or down-time necessary on mechanically operated devices.

They protect against irritating interruptions of regular maintenance caused by needless blows. Unnecessary repair work is reduced because — if trouble occurs, Fusetron fuses open and warn of danger before motors or equipment are damaged.

Panels and switches are protected against damage due to poor contact heating.

To Top Management
Fusetron Fuses Offer Reduced Costs

Fusetron fuses cut maintenance costs because they are maintenance free — they increase life of equipment by guarding against damage caused by electrical faults — and they lower production costs by eliminating shutdowns due to needless blows.

They save waste of space and money by permitting use of proper size panels and switches, instead of oversize.

FOR LOADS ABOVE 600 AND UP TO 5,000 AMPS . . . USE BUSS HI-CAP FUSES . . .

They have unlimited interrupting capacity to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

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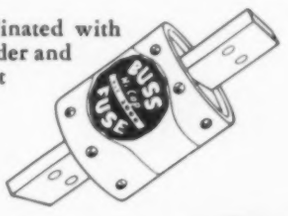

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TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
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UNIVERSITY AT JEFFERSON ST. LOUIS 7, MO.

(*Continued from page 129*)

for scheduling tests and recording the results and the maintenance steps taken, it will soon be part of our overall production maintenance program. Whether it is for the ball mills, the pan or hammer mills, the firing, or for the auxiliary production units such as the dust collectors or conveyor lines, everything relating to production leans heavily on the proper uninterrupted functioning of electric motors. The majority of these —ranging from fractional to 75 hp— can be rated as critical, from the production standpoint.

To the essential circuit breakers and other safety devices with which our revamped power distribution system is fully equipped, we recently added a portable testing unit known as the multi-amp. This device makes it possible for us to check circuit breakers, heater elements and other components of the electrical system and its control and safety devices *without removing any of them from working positions.*

That is an important factor, from the production standpoint, when it is borne in mind that the best mechanical, magnetic or similar automatic safety device can be subject to efficiency impairment by such elements as oxidation, dust, etc. Such impairment can be present without detection by visual and mechanical checking because the settings and readings may still appear to be correct. Often only an electrical test— by risky phantom load methods or by removal from the line—will uncover differentials between readings and actual ratings.

The New Testing Dimension—The multi-amp consists of a multi-tap stepdown transformer whose input is varied by a powerstat. High current-low voltage is made available at a panel of threaded terminals to which lugged cables are connected. The unit then supplies controlled continuously variable currents in a number of ranges, from 12.5 amp at 0 to 200 volts to 1000 amp at 0 to 2.5 volts.

Because current is the regulating factor in either thermal or magnetic protecting devices, low voltage will serve full well for test purposes. With the multi-amp the current is supplied only to the circuit breaker, heater element or other component being checked—without the risk of overloading the motor, transformer or any other part of the system.

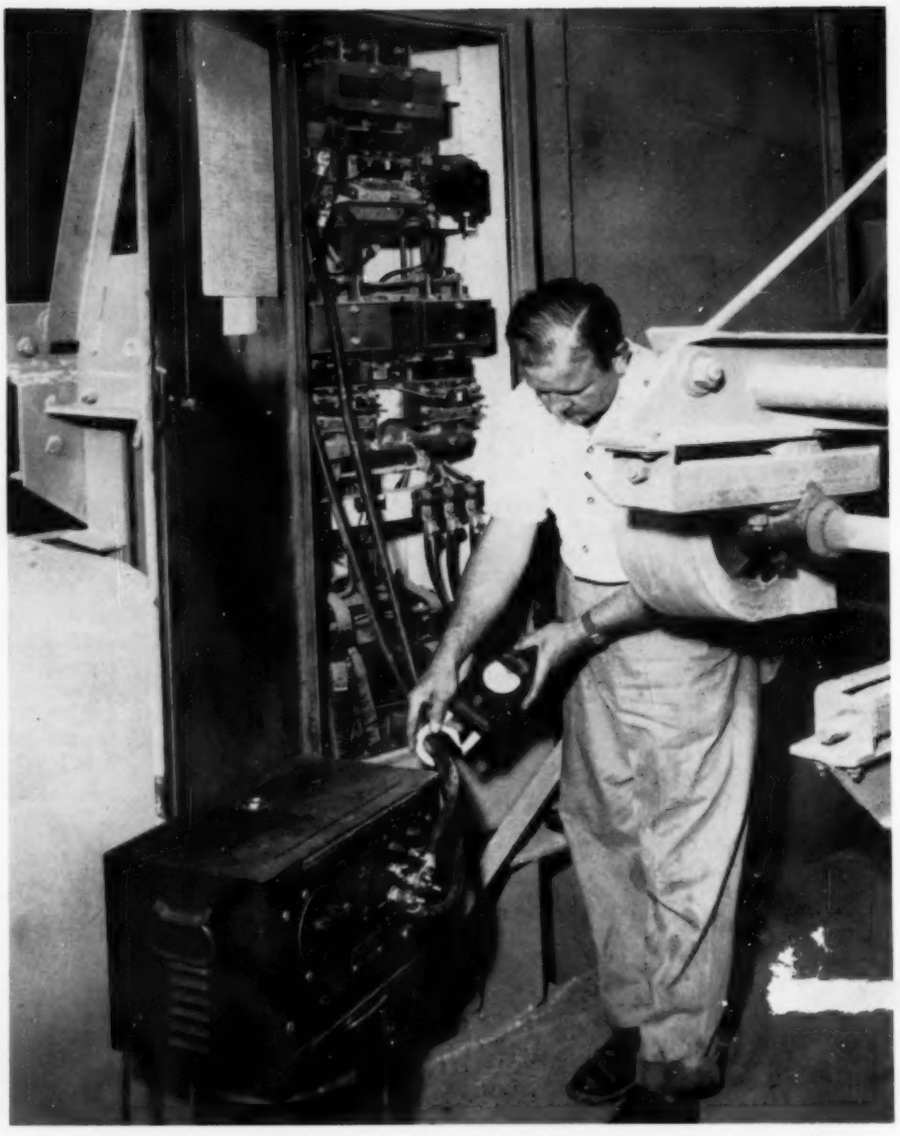


Figure 1 — Multi-amp testing device is shown being used to check setting of overload trips in autotransformer type starter for 75-hp high-torque motor driving 9-ft diameter pan mill.

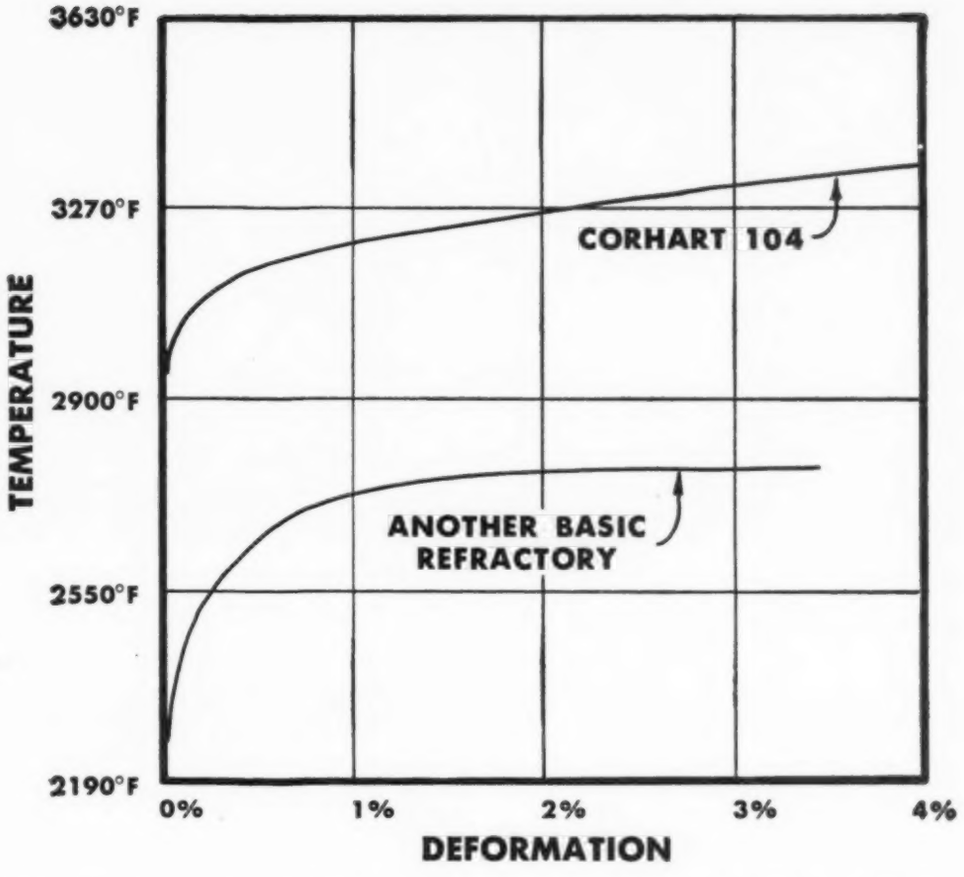
Circuit breakers can be checked before installation, to make absolutely sure the settings are correct; that is, low enough for safety, but not so low as to kick out unnecessarily.

For A Full Program, Add Control —Working with management control specialists from Remington Rand Inc., the makers of the multi-amp have drawn up a simplified system of production maintenance control records — to show inspections and tests scheduled, frequency of tests made, the results, the details of completed servicing (cleaning, oiling, minor repairs, etc.) and an historic record upon which maintenance can soundly base orders or recommendations for major repairs, replacements and extensions of facilities.

A pair of kardex cards serves as the control and scheduling record on each safety device and other units covered by the productive maintenance program. Except when they are taken along with the portable testing unit for on-the-spot inspections (or tests) and postings, the cards are housed on panels and mounted so that there is visible indexing of item, stock number and location in plant. The cards—a buff-colored 8 x 5 in. unit for the electrical test record on overload relays and circuit breakers, and same-sized light blue one for the inspection schedule and the mechanical check-list on motor starters and circuit breakers—thus provide an always-current charting of the planned maintenance program, to show just what has been done and to indicate situations requiring management review and decision.

Hot strength in a basic refractory?

YES!



CORHART 104 is a new magnesite-chrome refractory possessing both volume stability *and* outstanding hot strength. As the test chart shows, Corhart 104 stands up extremely well at 3000°F.

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Hot strength is only one of many advantages offered the metallurgical industry by this new refractory. Let us tell you the whole story of how Corhart 104 may improve your furnace performance and lower your costs. Write direct for full details.

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QUALITY ECONOMY ENDURANCE

CORHART 104 ELECTROCAST REFRACTORY

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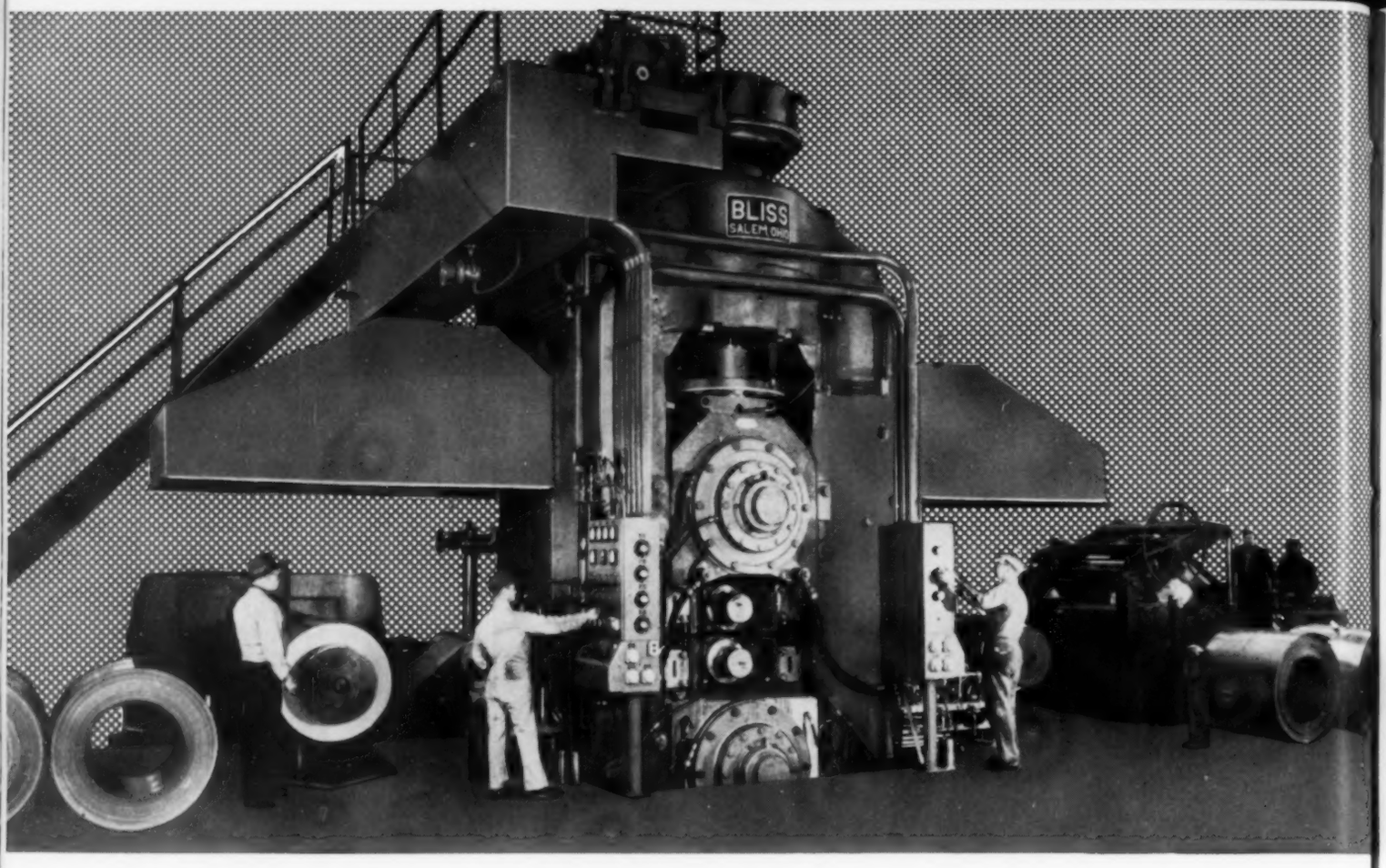

***Each minute*... up to 1700 feet of cold rolled steel from**

Newport Steel's New Bliss Cold Reversing Mill

This big Bliss mill has proved out "above expectation" in early test runs, and is now operating full time at Newport Steel Company's Newport, Kentucky, mill.

Working at speeds up to 1700 feet per minute, it reduces hot-rolled pickled strip in various gages and up to 48" widths. Its automatic coil handling equipment on both the entry and delivery end keeps pace with mill speeds, and is capable of handling coils up to 40,000 pounds.

Like all Bliss cold reversing mills, this Newport, Kentucky, installation is significant for its ease of operation. The mill is designed for fast changes, and centralized controls make possible virtually instantaneous adjustment while the mill is in operation.

This is just one of a complete line of Bliss rolling mills and accessories for both ferrous and nonferrous applications: two-high, four-high and cluster mills of Bliss manufacture are found in leading metal-producing plants throughout the world.

If you're interested in seeing how others have solved difficult cold and hot rolling problems, write for a copy of our recently revised Rolling Mill Brochure (Bulletin 40-A).

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Air Force Reaches Half-Way Point in Heavy Press Program

▲ Two hydraulic forging presses of 35,000 and 50,000 ton capacity were put into production at Aluminum Co. of America's Cleveland works on May 5, and the $40,000,000 installation became the first complete plant of the Air Force's $279,000,000 heavy press program to get into operation. This marks the half way point in this program. By the end of the year, all presses in the program are expected to be operational.

Of the ten presses in the program started by the Air Force in April 1951 —six extrusion and four forging— three forging and two extrusion presses are already in operation.

These are, in addition to the 50,000 and 35,000 ton presses operated by Alcoa in Cleveland:

1. A 35,000-ton forging press operated by Wyman-Gordon, North Grafton, Mass., which started this spring.
2. A 14,000-ton extrusion press at Alcoa's Lafayette, Ind. plant which started making aircraft extrusions in May 1954.
3. A 12,000-ton steel extrusion press at Curtiss-Wright's Buffalo, N. Y. plant now undergoing final test operation.

Until early this year the largest closed die forging press operating in the U. S., was an 18,000-ton press leased by the USAF to Wyman-Gordon at North Grafton, Mass. Completed in 1946, it is turning out wing spars and ribs, landing gear wheels, struts and trunnions, bulkheads, impeller and compressor wheels and supports for fighters and bombers currently in production for the Air Force and Navy.

The Soviet Union is known to have a 33,000-ton press which the Soviets removed from Germany following World War II. A 55,000-ton press was designed by the Germans but not erected before the war ended. This design, along with many top ranking German technicians, is believed to have also fallen into the hands of the Soviets.

Figure 1 — These two giant presses will now provide vital production facilities for aircraft structural components at the USAF Heavy Press Plant at Alcoa's Cleveland, Ohio works.

Figure 2 — The Mesta 50,000-ton hydraulic closed die-forging press was put in operation on May 5.

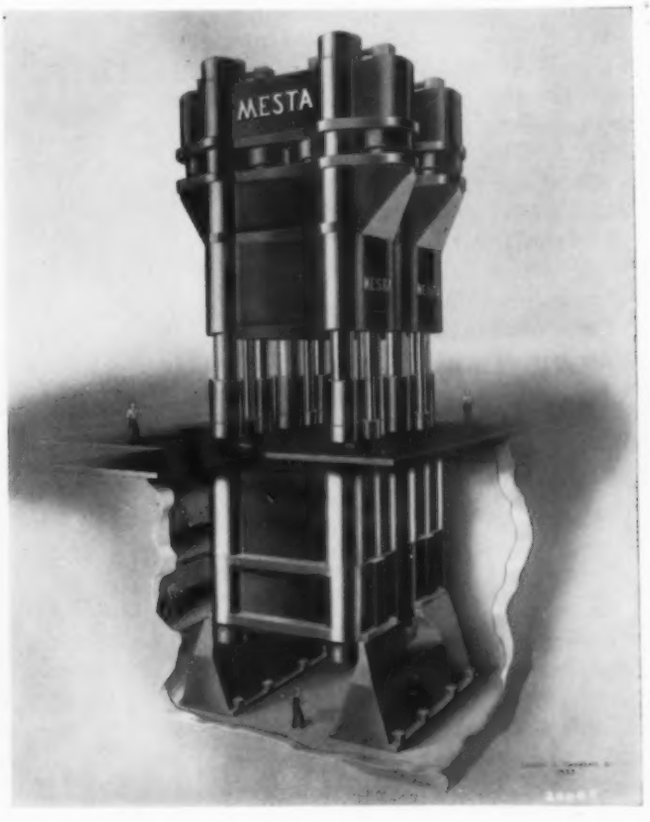


TABLE I

Forging Presses

Operator	Location	Builder	Press (Tons)	Operational date
Wyman-Gordon	N. Grafton, Mass.	Loewy	50,000	Aug. or Sept. 1955
Wyman-Gordon	N. Grafton, Mass.	Loewy	35,000	Spring of 1955
Alcoa	Cleveland, Ohio	Mesta	50,000	May 1955
Alcoa	Cleveland, Ohio	United Engineering	35,000	May 1955
Extrusion Presses				
Alcoa	Lafayette, Ind.	Schloeman	14,000	May 1954
	Halethorpe, Md.	Loewy	8,000	Sept. 1955
	Halethorpe, Md.	Loewy	8,000	Sept. 1955
Harvey	Torrence, Calif.	Lombard	12,000	Oct. or Nov. 1955
Harvey	Torrence, Calif.	Loewy	8,000	Oct. or Nov. 1955
Curtiss-Wright	Buffalo, N. Y.	Loewy	12,000	May 1955

A complete listing of the press program is given in Table I.

At Cleveland, the 35,000-ton press, built by United Engineering and Foundry Co. of Pittsburgh, and the 50,000-ton press, constructed by Mesta Machine Co. of Pittsburgh, are capable of making larger and more precise forgings than ever before possible.

Heavy precision forgings mean stronger, lighter and less expensive components for all types of modern military aircraft. Their size will permit one-piece construction of airframe parts which formerly required several pieces. Precision obtainable through the 35,000 and 50,000 tons of forging pressure will reduce previous requirements for expensive machining.

Mr. Wilson said Alcoa hoped to develop civilian products which can be made during periods when military production is not filling press capacity.

Alcoa served as the Air Force's prime contractor in building the Cleveland plant alongside an Alcoa works which has been in operation for more than 40 years.

Construction of the new plant started in May, 1953, and was completed within original budget limitations. Alcoa will operate the plant under a lease, which returns to the Air Force 4 per cent of the company's gross sales from products made on the presses.

OPERATION

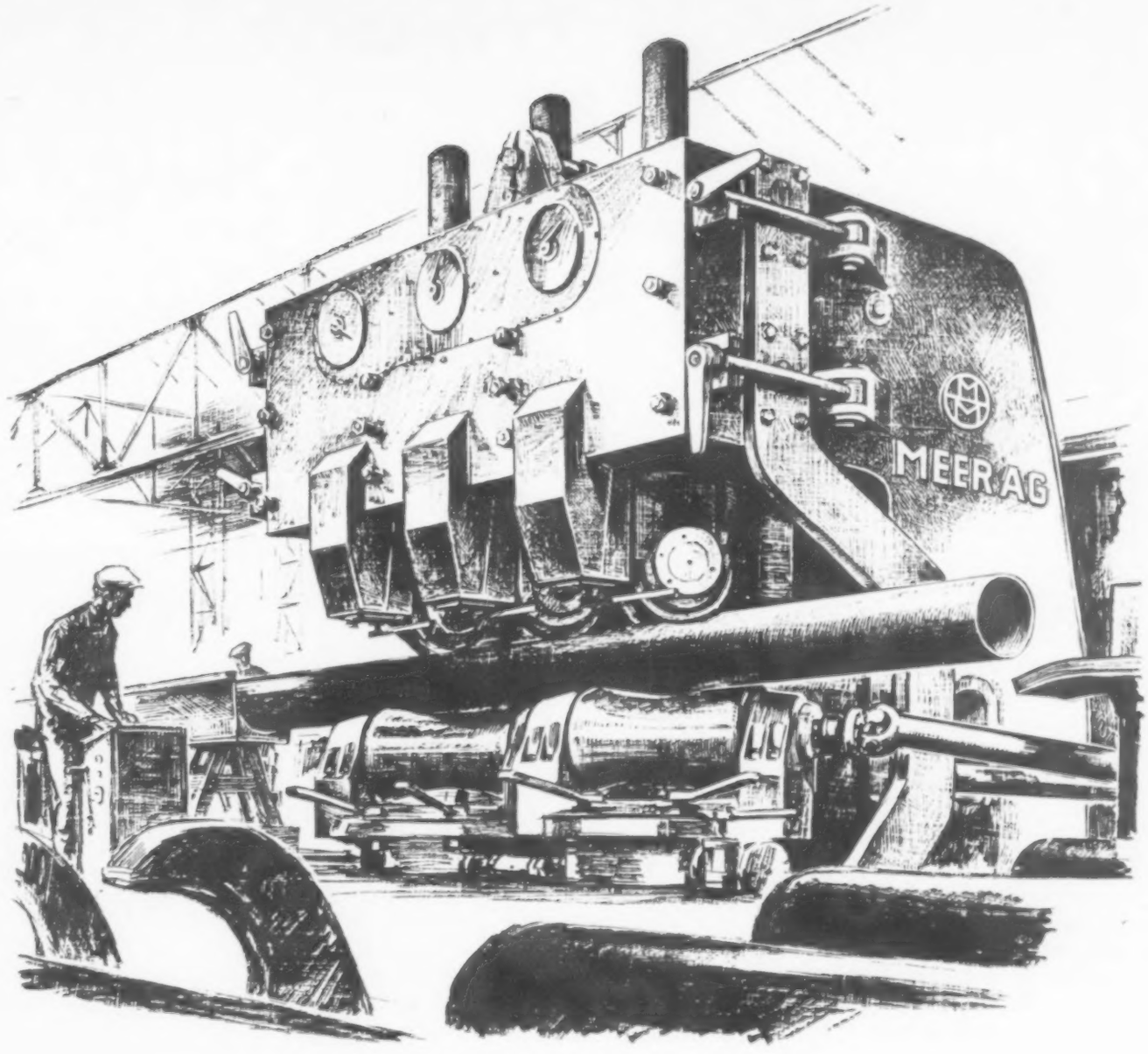
The sprawling United States Air Force heavy press plant is adjacent to the Cleveland works of Aluminum Co. of America. The entire plant, which has 12 acres of floor space under its roof, was built to support the operation of the two mammoth forging presses. Equipment is present to prepare the tremendous forging dies required. Large furnaces are available for heating the billets, and others are available for heat treating the forgings after they have been hot-worked. Presses for straightening and trimming the forgings have been installed. Extensive scientific testing equipment will insure structural quality in the aircraft sections squeezed out on the presses. Cranes of all types and sizes, lift trucks and animal-like manipulators will handle the forgings and service the forging equipment.

To produce the large ingots required to operate the Air Force plant, Alcoa has invested $4,000,000 in additional ingot casting facilities at the Cleveland works. Four, 40,000 lb capacity remelt furnaces were installed in the ingot plant for melting scrap and pig. Also being installed is a new direct-chill ingot casting unit to permit casting of more and larger ingots by that method. After the ingots have been cast, they are cooled and shipped to the nearby heavy press plant on rail cars.

The ingots are unloaded in the metal preparation area for the first step in forging production. This step involves cutting the ingot or billet to size on large saws, and if necessary, performing some preliminary machining on lathes. Before sawing, all cast ingots are heated in a soaking furnace to prepare the metal for forging. These ingots are also scalped (outer surface machined away). Before leaving this department, the billets are carefully checked to insure metal soundness.

Once through the metal preparation area, the billets are heated to closely controlled temperature limits before being subjected to the first forging operation. Each of the two giant presses is supplied with heated billets by a battery of three continuous heating furnaces. The large gas-fired furnaces are equipped with slat-type conveyor hearths and have four controlled heat zones. As the heated billets emerge from the fur-

Figure 3 — This battery of tracer-controlled die-sinking machines cut the forging cavities in steel die blocks.



New Straightener Line Speeds Mill Production

Mannesmann-Meer's new line of vertical skewed roll rotary straighteners handles a wide range of tubing and bar stock sizes in one single pass at high production speeds. Special hyperbolic shape of straightener rolls provides for extra length of contact between roll surface and work piece, improves the surface quality and prevents yield marks which ordinarily result when stressing material through the elastic limit. Even thin-walled tubing made of non-ferrous metals and liable to easy fracture are straightened with best result. The close roll spacing made possible by this new design combined with heavy anti-friction roll bearings accomplishes the best possible straightening effect, even on high strength steel tubes and bars. This new straightener incorporates the most advanced design yet developed and comes as a result of the combination of

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- DESIGN EXPERIENCE
- OPERATING BACKGROUND
- AMERICAN MANUFACTURING SKILL

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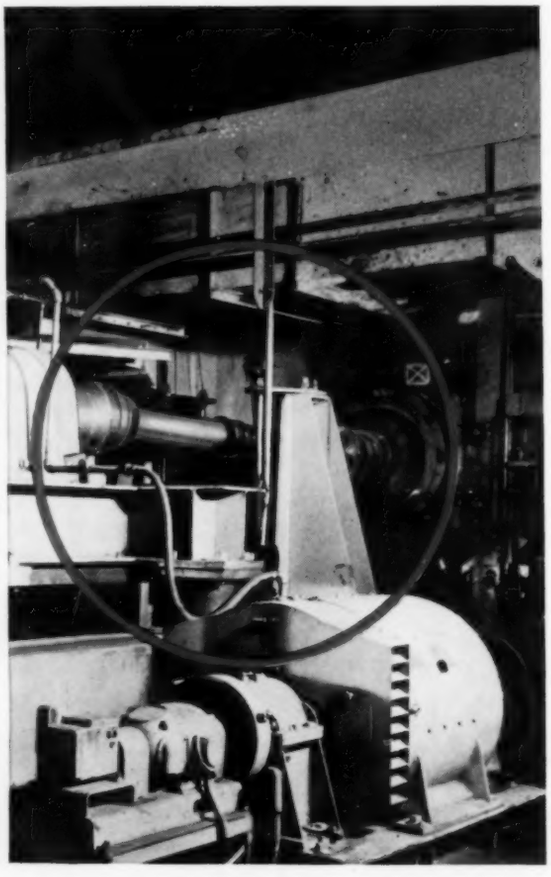
DIHEDRAL SPINDLE SHAFT COUPLINGS

Mill operators are amazed at the sensational performance of Ajax Dihedral Spindle Shaft Couplings in eliminating breakdowns and avoiding costly unscheduled downtime.

Equipping mill roll drives with Ajax Dihedral Spindle Shaft Couplings is a major step in preventive maintenance to assure full capacity output from rolling mills.

Photograph shows the first stand of a two-stand tandem tin temper pass mill designed and built by E. W. Bliss Co., for Jones & Laughlin Steel Corporation . . . Aliquippa Works. This mill was designed to be the fastest temper pass mill in the world with operating speeds over a mile a minute. Conventional couplings were replaced by Ajax Dihedral Spindle Shaft Couplings and speed was stepped up over 1000 F. P. M.

Ajax Dihedral Spindle Shaft Couplings are making all other types of conventional couplings obsolete. Their uniform peripheral speed, ability to handle maximum misalignment with tooth clearance limited to lubrication film requirements, elimination of vibration and minimum maintenance are reasons why mill operators are welcoming Ajax Dihedral Couplings with open arms.



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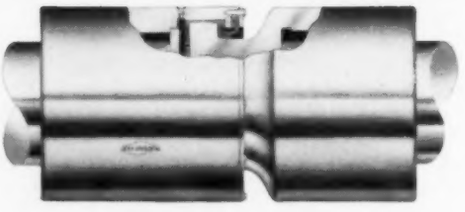

Cut-away view of Ajax Dihedral Coupling showing arrangement of teeth.

PATENTS PENDING

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WESTFIELD, N. Y.

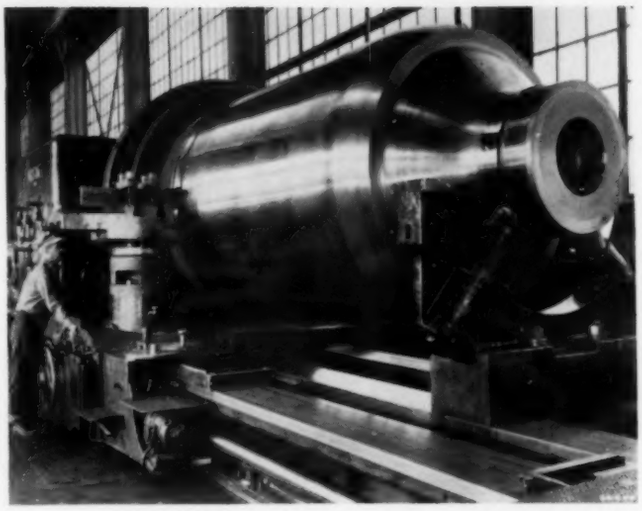

Figure 4 — Finishing one of the eight forged alloy steel pressure cylinders on a 110-in. turning and boring lathe. Each cylinder was machined to an inside diameter of 5 ft-0½ in. and 11 ft-7½ in. long.

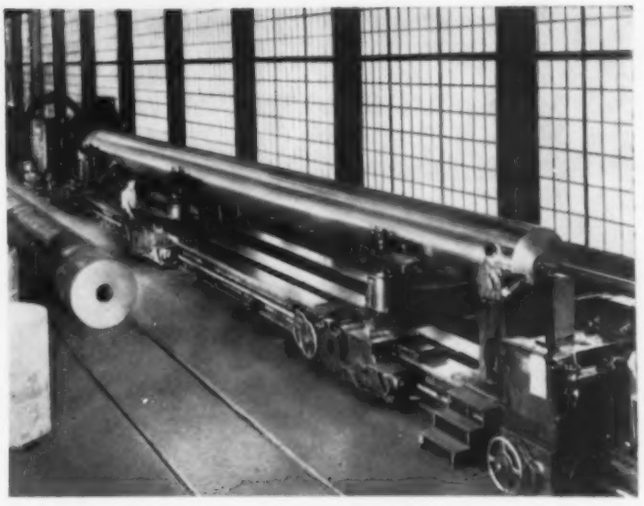

Figure 5 — Turning and trepanning a 10-in. diam hole through a press column on a 96-in. turning and boring lathe. The eight columns were finished to 40 in. diam x 76 ft long.

naces, they are brought to the forging press by a manipulator or by a manually controlled crane.

Both the 35,000 and the 50,000-ton forging presses are equipped with manipulators which can pick up hot billets from the heating furnaces, carry them to the bed of the press, and place them in the forging dies.

Forging operations on the heavy aircraft forgings generally require at least two separate steps. The first, or blocking operation, forms the metal in closed dies into the general shape of the forging.

After blocking, the forging usually goes to in-process trimming where it is either trimmed with a saw or in a trimming press. After surface defects are removed the forging is etched in large tanks. Next, the forging is returned to the heating furnaces to be reheated. One or possibly two additional forging operations are generally required to achieve a high degree of precision in the part. This would involve a finishing operation or possibly a second blocking operation, followed by finishing. Each operation normally requires a separate set of dies.

After the forging operations are completed, the parts are given a finish trim and etch, and transferred to the heat treating department.

Heat Treating — The Air Force plant is equipped for production solution heat-treating and aging of the heavy aluminum forgings. To do this job, four batch-type solution treating furnaces have been installed. For artificial aging of the forgings, eight batch-type furnaces have been provided. The two-to-one ratio of aging furnaces and solution treating units arises from the fact that aging requires about twice the time cycle of solution treatment. The two-to-one ratio allows a continuous production cycle.

The solution treating furnaces were built with the heating chamber directly over the quench bath, allowing almost instantaneous quenching of the forgings. The parts are loaded in the electrically heated solution treating furnaces in alloy steel trays. After solution treatment is complete, a transfer car picks up the trays of forgings and carries them directly into one of the gas-fired aging furnaces.

After the completion of heat-treating operations, the forgings are again etched. They are then delivered to final inspection for a careful check for quality, and necessary final finishing operations. These may include: straightening of the forgings; ultrasonic reflectoscope testing; finish grinding or machining; and final etching treatment, if necessary. Forgings are then delivered to the shipping department for packaging and shipment.

Figure 6 — The massive stationary crosshead is being lowered into position over eight pressure cylinders and eight columns.

Forging Dies — Approximately 115,200 sq ft of the total area (526,350 sq ft) in the new heavy press plant is devoted to production of the forging dies. Located in this area is over $6,000,000 in die sinking machinery. It is probably the biggest single shop in the world devoted exclusively to the production of large forging dies.

THE MESTA 50,000-TON HYDRAULIC CLOSED DIE-FORGING PRESS

The 50,000-ton forging press is 87 ft high, extending 36 ft below ground level and 51 ft above. The total weight of the press is approximately 8,000 tons. Sixteen huge steel castings poured in the Mesta foundries at West Homestead, Pa. comprise the major sections of the forging press. Over 700,000 lb of steel was required to pour some of the largest castings.

Coming up from the subterranean foundation, two cast steel "stools" carry the press proper. Mounted on these are two lower base and two upper base sections. The movable die table or platen which holds the lower forging die, is attached to the base sections. The die table, 12 ft wide x 26 ft long is withdrawn only

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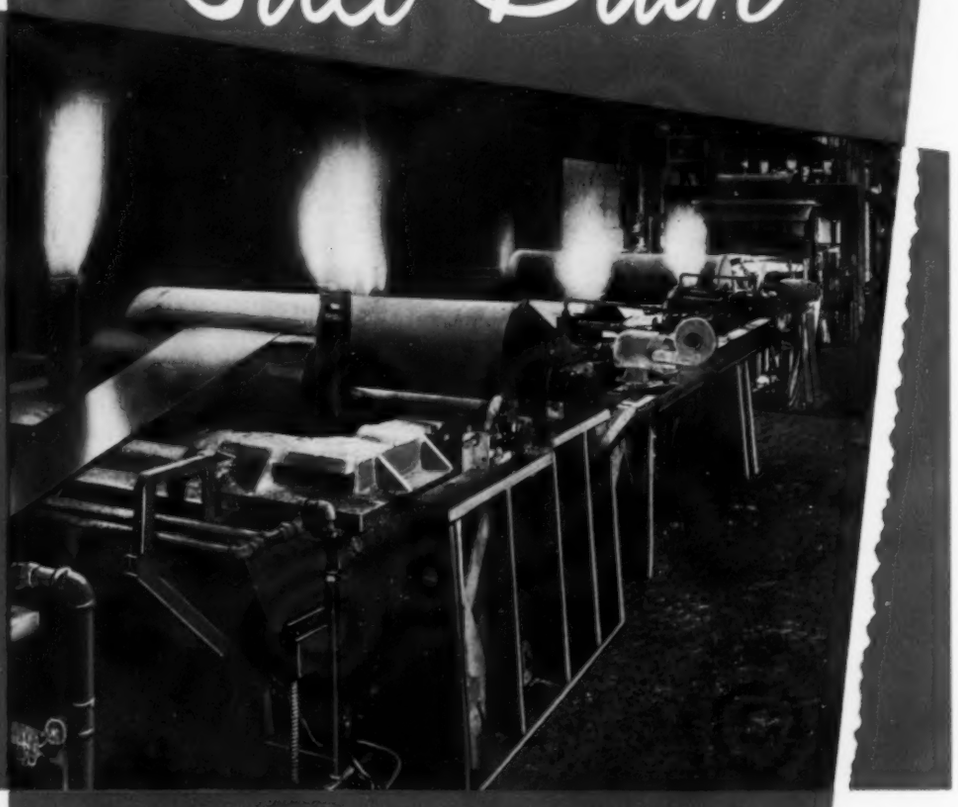

Equipment shown descales 18,700 lbs/hour cold reduced stainless strip 62" wide x .078" to .005" gauge. Maximum operating temperature of bath—950°F

The above 35'-0" long Drever Continuous Descaling Bath will descale 18,700 lbs/hour when strip enters bath at bath temperature. Entering strip temperature is controlled by regulation of quenching temperature after strip is discharged from a catenary annealing furnace.

Drever descaling baths are heated by gas-fired immersion tubes with proportioning automatic temperature control.

Other baths are supplied for continuous or batch operation for strip, plate, wire, tubing and other ferrous or non-ferrous products.

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when the forging dies are changed. Forged parts are removed and ingots inserted between the dies by a manipulator moving on rails. The maximum press stroke is six ft with a working stroke of one foot designed to operate at 30 cycles per hr.

Above the movable die table are the fifteen ft of opening between the jaws. The upper die is clamped to the upper platen which is attached to the lower moving crosshead.

The entire moving crosshead assembly consists of eight steel castings totaling almost two and a third million pounds.

Above this assembly are the stationary crossheads housing the eight main hydraulic pressure cylinders.

Running through the press from top to bottom are eight alloy steel columns, formed in a series of heat treating and forging operations, in one of the Mesta forging plants at West Homestead, Pa.

So true were the column forgings that a perfect finish was obtained by removing only one inch of stock from the forgings of the Mesta 96-in. lathe, one of the world's largest. Each column was trepanned full length, to remove a core 6-in. in diameter from the 10-in. diameter hole. The columns were finished to a diameter of 40 in. and a length of 76 ft. Four sections of each column were threaded and fitted with four steel nuts, each 52 in. in diameter. Eight of the largest nuts weigh 111,000 lb each.

The press force is generated by the hydro-pneumatic pressure system consisting of four-pre-filler bottles, two horzontal reciprocating pumps driven by 1,500-hp motors, and four forged alloy steel pressure accumulator bottles. The hydraulic fluid is water with a small percentage of soluble oil added to keep the system rust-free and lubricated. A pressure of 4,500 psi is built up in each accumulator and released to the eight pressure cylinders housed in the stationary crossheads at the top of the press. The combined effort of these cylinders produces the 50,000-ton forging capacity.

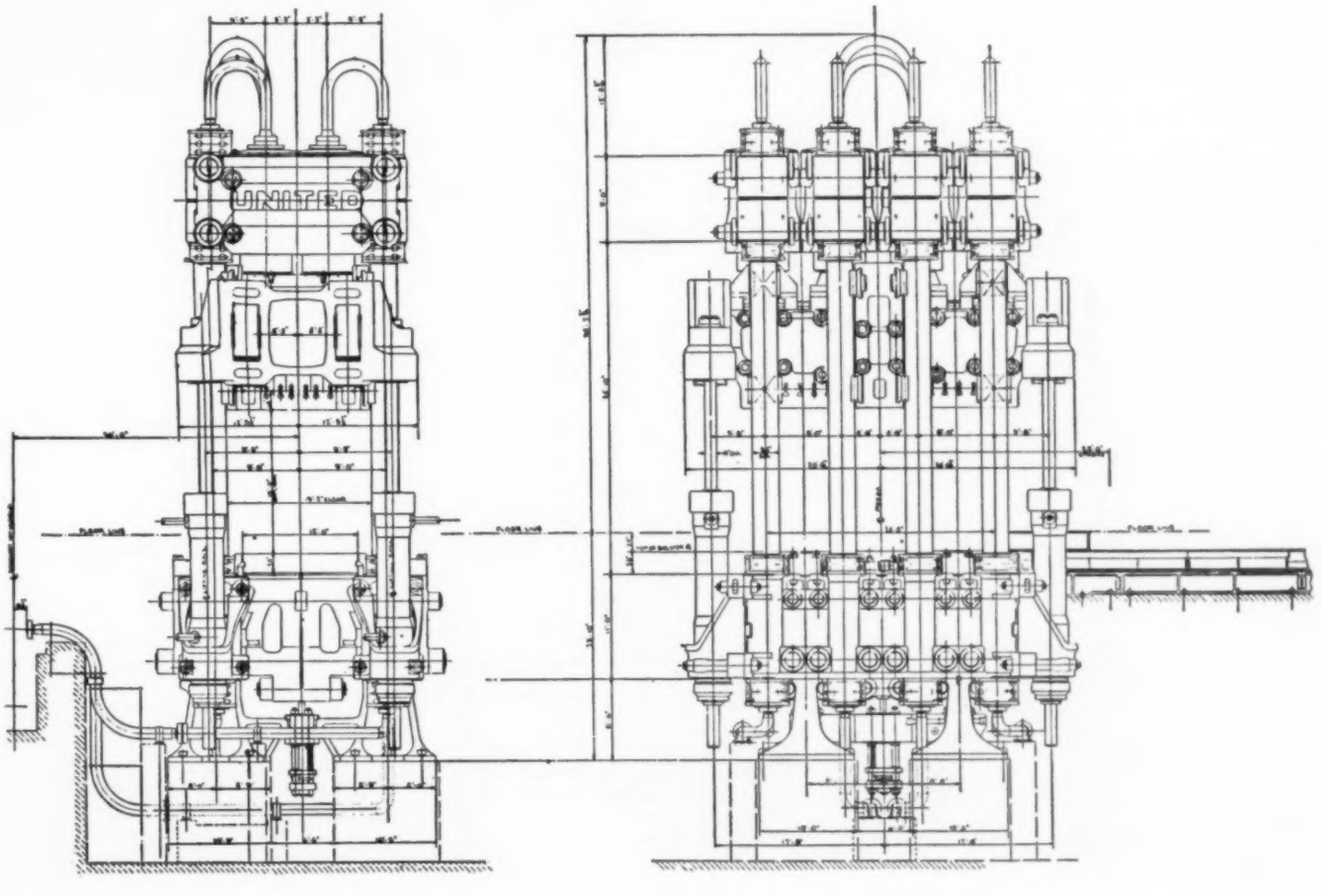
At the end of the press cycle the hydraulic force is reversed and directed to eight pull-back and balancing cylinders which lift the moving crosshead assembly to its upper position.

THE UNITED 35,000-TON DIE FORGING PRESS

There are some significant differences between the more usual open forging press and the die-forging press. The die-forging press, because of the high specific pressures required to fill the dies properly, especially where light thin-walled sections are involved, are considerably greater in tonnage capacity relative to entablature area. As an example, the 35,000-ton die-forging press in question has a platen area of 24 ft x 12 ft, corresponding to a significant figure of about 120 tons per sq ft, whereas a comparably large open forging press built in World War II, rated at 14,000 tons, has a platen or entablature area of 23 ft x 8 ft-6 in. corresponding to about 70 tons per sq ft.

Whereas open forging presses, especially for steel, and for other metals as well, must include the possibility of rapid stroking and accurate position control, these are of no concern in a die-forging press, velocity control during stroking being the particular requirement and forte of the latter. Another characteristic dif-

Figure 7 — 35,000-ton Forging press.



ference between these two types of presses is in their daylight requirements, which is the clear distance between bolsters. The United 14,000-ton open forging press, which is used primarily for armor plate bending, has a maximum daylight of 24 ft, whereas the current 35,000-ton die-forging presses will have a daylight of 15 ft maximum. This new press will reach open-forging-press speeds of 10 ips idling, and 2½ ips under full pressure.

Die Forging Press Construction— The 35,000-ton press, with possibilities of ¼, ½, ¾, and full pressure operation, without resorting to the extra complication of intensifiers, has 8 cylinders and 8 columns, essentially, comprising four 2-column press units, insofar as the top entablature is concerned. This permits full proportional stressing of all columns—the units being free to stretch vertically independently of one another, yet keyed and bolted against lateral movement. Columns are 34 in. diam x 61 ft long approximately, of forged steel, bored so that main fluid medium for hydraulic system flows through column which acts as a pipe as well as main tension unit of press. Press is about 52 ft above floor and extends down under floor level some 34 ft, has an over-all entablature dimension of some 40 ft long x 30 ft wide, with a tool changing gear that extends outwardly from side of lower base entablature some 65 ft.

Further points in general construction are to be seen in the cylinder and ram construction. The cylinders are supported at the top, rather than on flanges at the open ends, eliminating a source of cylinder failure, creating a generally improved cylinder stress condition, and minimizing cylinder distortion associated with packing-leakage problems. Further, all cylinders have pintle-type articulated rams, thus preventing any lateral distortions from unduly and adversely affecting packing performance and cylinder wear.

The forged columns serve dually as press columns and pressure piping. The press is clear of heavy piping surrounding the press, thus permitting the clean design achieved by locating both prefill and operating valves below the press and handy to the press operator. Columns, however, must be designed properly, particularly as to the refinements in thread design, and securely attached to top and bottom entablatures. The accepted practice is to shink them between top and bottom nuts at initial loading significantly in excess of the maximum forging loads; this prevents any working of the joints under continued operation of the press.

Press Maintenance — The matter of press maintenance must be recognized in the initial design of such large pieces of machinery. Of first importance is the possibility of maintaining and changing cylinder packing. This is accomplished by providing excess crosshead stroke so that the entire crosshead may be lowered well below the nominal low position, to permit the internal packings to be exposed for servicing.

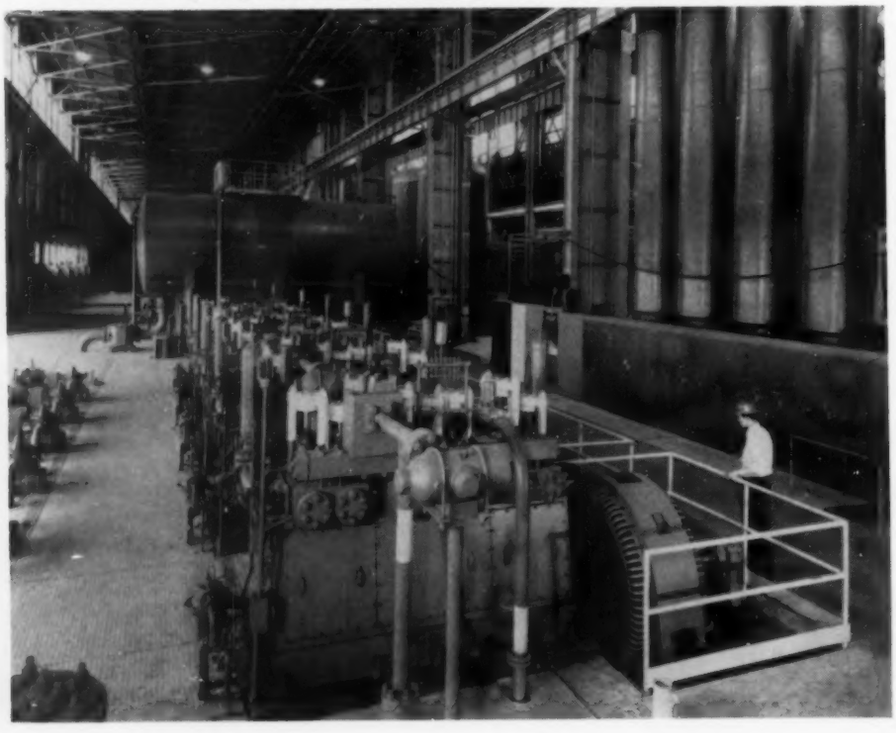
Ejector cylinders necessarily are furnished for die-forging work, there being three 300-ton ejector cylinders in the base, and one 150-ton ejector in the moving crosshead. Overriding both, if necessary, is adequate stripping capacity in the press proper, when using pushbacks for raising the platen, to free any stuck forging. The reason for the higher-capacity ejector in the bottom of the press is that the major part of all the cavities will be confined to the lower die, the three cylinders being operated by three separate cylinders fully mechanically equalized so that the full 750 tons can be exerted on a single chunky piece or distributed over long pieces, all ejector rods rising together to maintain straightness in ejection.

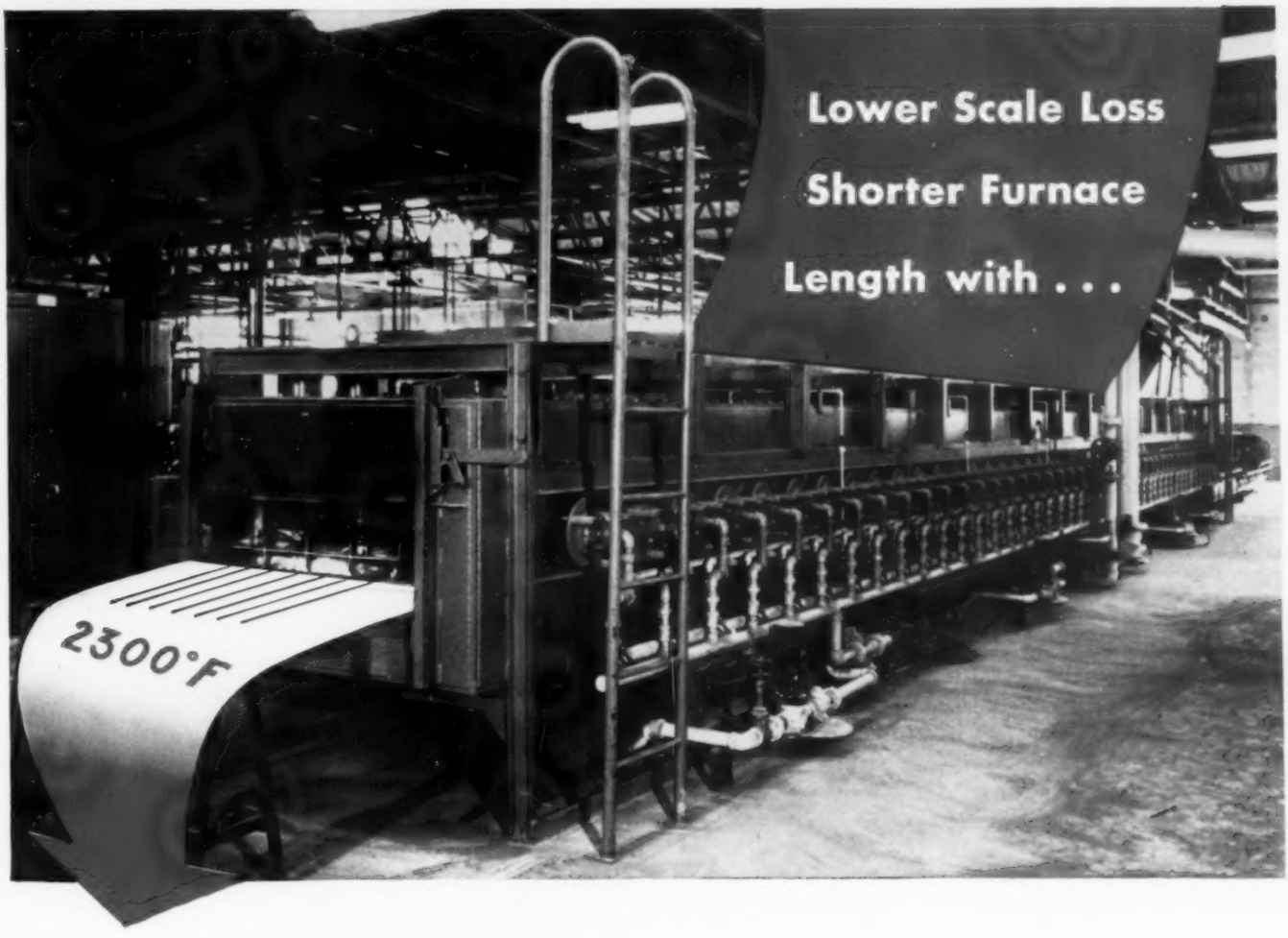
In this press, about two-thirds of the total weight is castings, and one-third forgings, the latter being principally the columns, cylinders, column nuts, major bolts, and the like.

The estimated total weight of the press proper is 5000 tons or 10,000,000 lb—the auxiliary equipment adding another 3,000,000 lb.

The moving crosshead or platen exemplifies the type of build-up construction referred to previously. Carrying the upper bolster, to which the upper die is attached, is a multiple-construction crosshead made up of five case I-beams 24 ft long, 9 ft high, 32 in. wide at the flanges, dovetailed and bolted together, with essentially full thickness webs in the middle-length section. This multiple unit is capped with three transition blocks between the crosshead and the cylinder pintles, the two outside ones carrying the outside pairs of cylinders, and the double-size central piece carrying the four central cylinders. This construction permits the reduced-capacity operation mentioned earlier, by proper valve selection, from the operator's pulpit. Accordingly, one-quarter and three-quarters capacity operation involves diagonal cylinder utilization of the

Figure 8 — Five 700-hp, 7-plunger pumps will power the 35,000-ton press. Two 1500-hp triplex power pumps will power the 50,000-ton press.





GASMACO wire patenting furnaces

GASMACO Wire Patenting Furnaces substantially reduce maintenance and operating costs and keep production at a steady pace. Elevated furnace temperatures heat faster; permit shorter furnace design and thus offer floor space bonuses.

Necessity of alloy muffle tubes eliminated. Indirect-fired GASMACO Patented Silicon Carbide Radiant Tubes virtually eliminate "down time," and supply high thermal head with atmosphere control over scale.

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central four, thus keeping all loads centrally symmetrical, and obviating the necessity for resorting to the use of separate intensifiers, with the objections of extra cost, maintenance, spares, and so on.

Special Requirements—A consideration of paramount importance that is being recognized more and more by designers and operators, as a mandatory specification from the outset, is that of permissible eccentricity of forging, as the so-called secondary stresses set up by eccentric forging may easily exceed the primary stresses due to central forging. Therefore it was specified that full pressure is to be exerted ± 2 ft off center along the long axis of the press, and ± 1 ft off center in the lateral direction. This means that proper provision must be made for a 35,000 x 2 = 70,000 ton-ft eccentric moment, in addition to full central pressure of 35,000 tons.

The uncertainty of being able to count on the eccentric moment being shared properly by all eight columns, as would be required in any mechanical scheme, led to the adoption of the hydraulic method of eccentric-moment equalization.

PUMPS

The two presses are powered by seven power pumps built by Worthington Corp. at their Oil City Works, to operate at a normal pressure of 4500 psi. Five of the pumps powering the 35,000-ton press at 229 gallons per minute each, are 700 hp 7-plunger vertical pumps. The two which power the 50,000-ton press are triplex-plunger horizontal pumps with a capacity of 490 gpm each, and are driven by 1500-hp motors.

STEEL INSPECTION at Timken Roller Bearing Co.

By OWEN G. SMITH

▲ A MAGNETIC inspection method for detecting seams, cracks, tears and other discontinuities in metals has been in use for many years. The method, known as magnetic particle inspection, is particularly adapted for the inspection of most iron and steel parts. Magnetic particle inspection is ineffective when applied to the austenitic types of stainless steels.

While magnetic particle inspection is widely used on finished machined parts and some specialty products, it never was used as an inspection tool on semi-finished steel in mill production.

Two methods of magnetic particle inspection are employed — the dry method and the wet method. In the dry method the work piece is magnetized and dusted with a fine magnetic powder. In the wet method the magnetic particles are suspended in a liquid and the work piece is either submerged or flushed with the liquid while magnetized.

A flaw in the surface of the work acts as a magnet and collects some of the magnetic powder. The defect's presence will be shown by the "build

Figure 1 — Traveling head (at right) magnetizes billets while piece is being coated with magnetic particles.

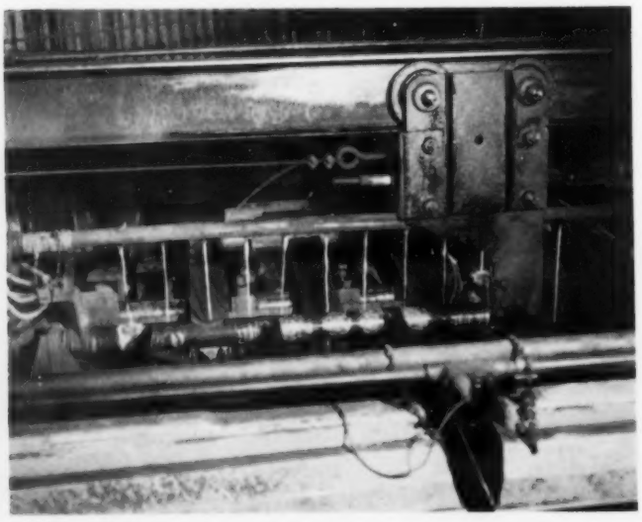

Figure 2 — General view shows magnaglo inspection unit.

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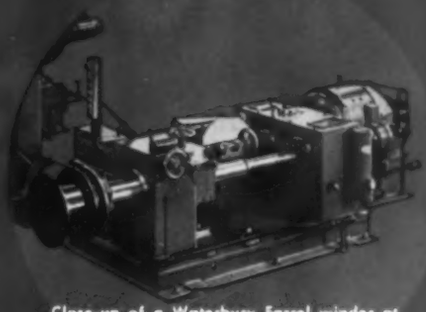


Close-up of a Waterbury Farrel winder at the delivery end of a WF Tandem Mill. Winder is provided with pneumatic clamping of reels. It has three adjustments for width of wire and width and positioning of drum or spool.

This complete Waterbury Farrel mill package includes 10" and 8½" Tandem Wire Flattening Mills, power driven double head Pay-off, Edger, Winder, footage counter, continuous thickness and width gauges and automatic electrical synchronizing control. Other WF tandems with up to five mills available.

Modern Waterbury Farrel Mill Design Insures High Production Plus Precision . . . Minimizes "Down-Time"

Here are some reasons why Waterbury Farrel Wire Flattening equipment can give you *more continuous,* high speed, precision production.

- Loading payoff and motor driven screwdowns for mills and edgers facilitate threading of wire with minimum effort and time.
- To protect precision operation, soluble oil is circulated internally and externally on the rolls and into coolant enclosures where wire is submerged. A refrigeration system maintains the coolant oil temperature at approximately 70° while a flotation unit keeps it clean and fresh. In addition, high speed mills also have a self-contained, automatically-filtered circulating mineral oil lubrication system for roll necks and drives.
- Transparent lucite covers at vital lubrication points such as gear cases and universal joints make it easy to check lubrication at a glance.
- Anti-friction bearings are used for all rotating members including the winder shaft. High precision anti-friction bearings are used on roll necks and edger arbors. This, combined with precision fitting of component parts enables WF mills to maintain tolerances well inside commercial allowance.
- Tungsten carbide ring rolls permit rolling the toughest alloys and increase roll life.
- Electric control keeps wire tension constant. Dancer rolls are used for fine wire.

Waterbury Farrel designs and builds a wide range of wire flattening mill equipment to suit specific requirements. Various sizes and combinations of single and multiple mill stands with auxiliary equipment are available for flattening ferrous and non-ferrous wire from the smallest diameters to 1" diameter and more. Speeds range up to and above 2500 FPM.

Write for further information.

WATERBURY FARREL FOUNDRY & MACHINE CO.
WATERBURY 20, CONN.
Sales Offices: Chicago, Cleveland, Millburn, N. J.

WATERBURY FARREL FOUNDED 1851

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WF 9

up" of particles around the flaws. Flaws which cannot readily be seen with the naked eye are thus easily detected.

In the one wet method the magnetic particles are treated to make them "glow" or "fluoresce" under an ultra-violet or "black light" of a particular wave length. Called "magnaglo," this is an ideal application for semi-finished billets or bars encrusted with the mill scale. The fluorescent build up stands out clearly against the dark background and makes inspection easy and positive.

The inspection and conditioning of round billets for the tube mills was the first use made of the magnaglo inspection process. Billet inspection and conditioning were combined which eliminated all handling by crane lifts.

Most tube mill billets were pickled, inspected and then conditioned in the bar conditioning department. Since the magnaglo unit handles material with the mill scale on, many intermediate handlings were eliminated. The billets go directly to the unit, are inspected, conditioned, then sent to the tube mill for charging. This eliminates handling in the pickling, inspection and conditioning processes.

Lead time between the bar mill to the piercing mill has been drastically reduced, thereby aiding delivery time of orders.

The magnaglo inspection unit is located adjacent to one of the piercing mills. The inspection unit schedule is integrated with the mill schedule.

A set of fingers picks off one billet at a time from the charging bed and rolls it to the magnetizing station, where a traveling electrode head pushes the billet aganst a stationary electrode head. It is thus magnetized. A tube with a series of nozzles is located above the billet through which the solution containing the magnetic particles is pumped. The billet is

Figure 3 — Magnetic particles build up around defect in billet making defect detection fast and positive.

thoroughly covered with the solution while it is being magnetized. The billet is then kicked off onto roll down skids and up against a stop, ready for inspection.

When the inspector is ready for this billet, he pushes a control button releasing the piece and allowing it to roll onto the inspection rolls. This release also sets in motion the release of the second billet for the magnetizing operation.

The billet is inspected on a set of revolving rolls controlled by the inspector under a battery of "black lights." As the inspection is completed and defects marked, the inspecting rolls are lowered and a conveyor roll table moves the billet away to the scarfing bed.

The scarfer works on a platform above the scarfing bed and controls the movement of the rolls. As a defect marked by the inspector appears in the proper position, it is cut out. After a billet has been scarfed, it is rolled out onto the discharge bed and removed by a fork truck. From the discharge bed the billets are either charged direct into the piercing mill furnace or stored in the ready yard.

The unit will handle a wide range of sizes and lengths with practically no adjustments for the different sizes.

The billets are magnetized with circular magnetism using a heavy duty power pack, built by the Magnaglo Corp. and having a capacity of 5000 amp with a 2000 amp continuous charge capacity.

Water used as the vehicle for carrying the magnetic particles to the billet. The magnetic particles were formerly suspended in oil. The fire hazard created by the use of oil, however, rendered that system impractical. Water, as the suspending agent, was also more economical than oil. The use of water presented a problem in extreme cold weather, when ice formed on the billets. Ice was temporarily eliminated by adding anti-freeze to the solution. Later burners were installed under the charging bed and billets were heated sufficiently to prevent freezing of the solution. The burners also melt snow and ice accumulated on the billets when they are stored in the outside laydown yards.

The working force for the unit consists of three magnaglo operators working as a crew and rotating on both jobs, thus relieving job fatigue and monotony.

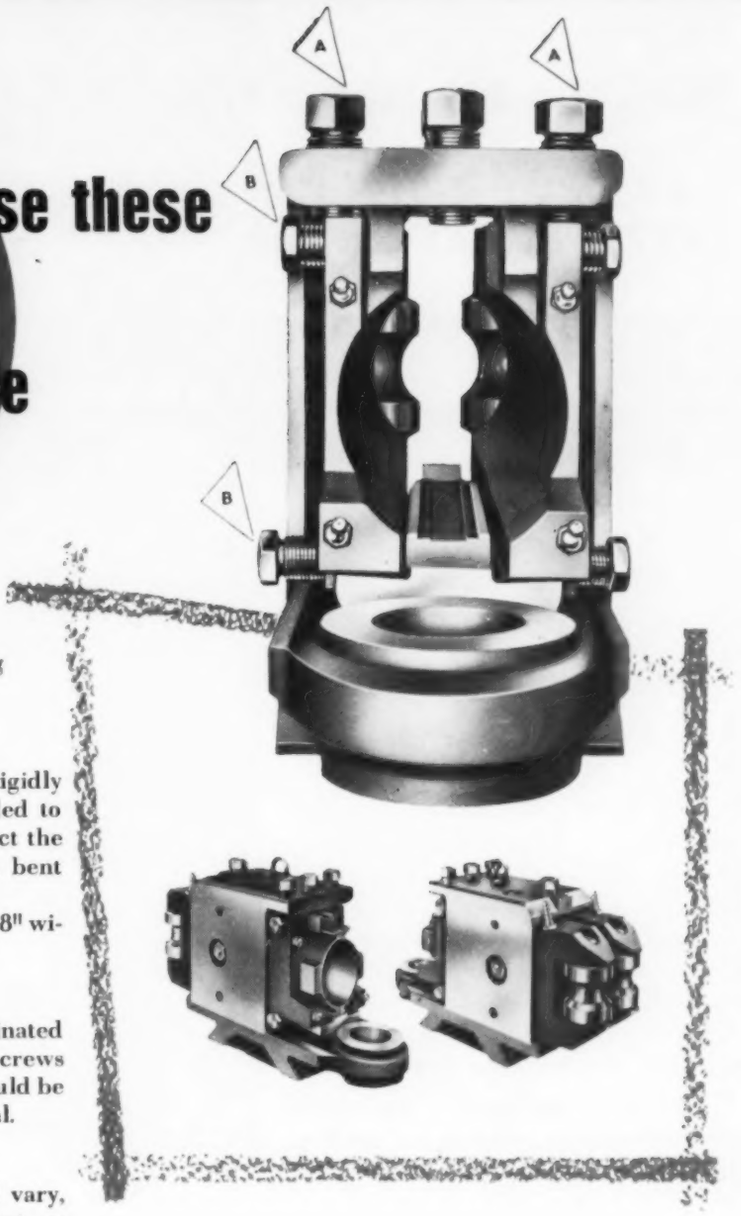
The same fork truck services both the unit and the piercing mill—the mill stocker foreman scheduling the unit to conform to the needs of the mill.

The magnaglo inspection unit will maintain an average of approximately 100 billets per gross hour over a month of production, and includes a wide range of sizes and lengths. This inspection system has reduced the cost of conditioning. Pickling has been completely eliminated. Handling has been substantially reached.

Most important, however, is the more thorough inspection of steel made possible by using the system. Immediate result of a more careful inspection process is, of course, a higher quality steel product furnished to the tube mills. Yield from the tube mill has been improved. This improvement is directly attributable to the unit.

Are you annoyed by having someone borrowing your magazine when you want it? Get him to join the AISE.

8 good reasons why you should use these ROLLER GUIDES in your bar or wire rod mill



The Morgårdshammar Roller Guides — patented in most countries of industrial importance — are constructed according to the following principles:

1 The entry friction guides are rigidly clamped into the guide box. They are intended to lead the oval to the groove in the roller, to protect the rollers against overloading, and to straighten bent rods.
The groove in the entry guides is made about 1/8" wider than the oval.

2 The rollers are mounted on laminated springs, which can be adjusted by means of the screws "B", and hold the oval steadily even if there should be some slight variation in the thickness of the oval.

3 If the thickness of the oval should vary, the springs of both rollers yield an equal amount, so that the oval remains in the centre of the groove.

4 To tilt the oval, the screws "A" are adjusted as shown by the arrows. One roller will then be lifted as much as the other is lowered.

5 As the oval is held very rigidly, the leader oval for wire rod may be plump, unless other circumstances call for a thinner oval.

6 The roller guide assemblies are narrow, and all screws that require adjustment during rolling are accessible from the front of the mill. No lateral space outside the guide box is therefore required for gaining access to the set screws, and the guide box assembly can thus be located close to the mill housing.

7 As the groove in the entry guides is wide and nothing but rolling friction acts on the oval, the latter is very easily introduced into the pass, and there is practically no risk of scratching the bar.

8 The roller guide may be used not only for leader and break-down oval passes but also for edging flats as well as for rolling squares, hexagons, octagons and various other sections, for instance in reduction passes for hexagon. It is suitable for all types of rolling mills. An important advantage is that the roller guide enables repeaters to be used in rolling plump leader-ovals.

P.S. Practically speaking, every bar and wire rod mill in Scandinavia uses roller guides of our design.

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK VERKSTADS AB • MORGÅRDSHAMMAR • SWEDEN

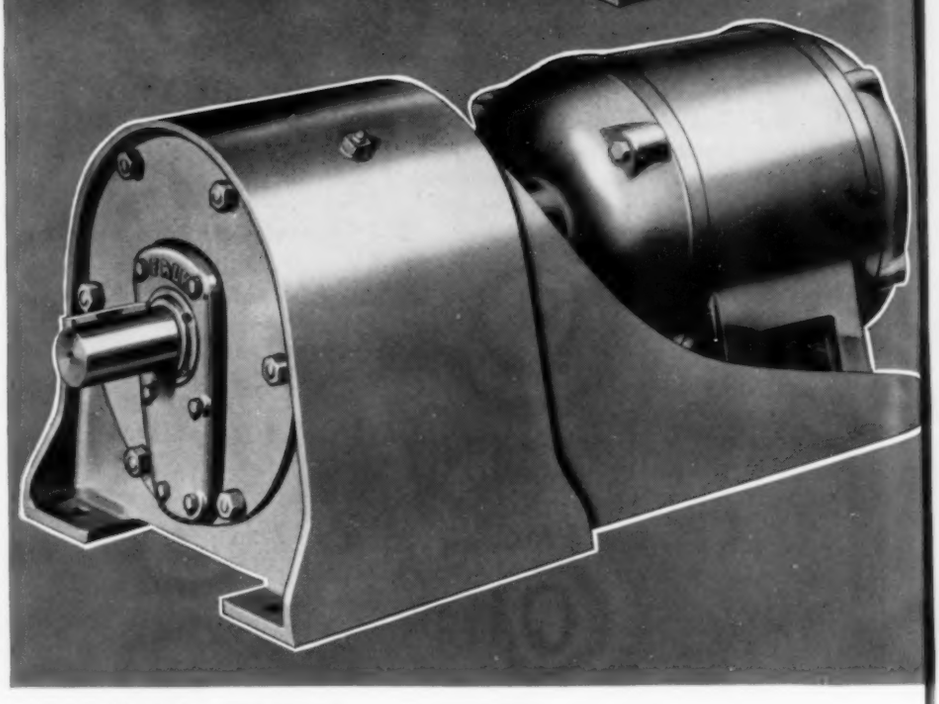
Telegrams: Morgårdshammar, Ludvika
Telephone: Ludvika (0240) 71100

For the complete story — send for your copy of bulletin L3—1E.

With the All-Motor Type,

ALL-STEEL FALK Motoreducer

you can interchange motors in minutes... *on the job!*

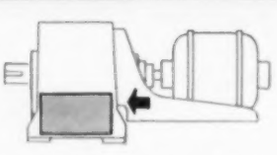


Fast, easy maintenance gives savings in time and money

With the *all-steel,* All-Motor type FALK Motoreducer . . . the only complete and compact motorized reducer with a separately mounted, resilient Steelflex coupling-connected motor . . . you can replace or interchange motors, *or even parts,* in minutes—*on the job,* without long and costly "down time"! Ratios can be changed (within capacity) without motor modification.

Any make, speed, or type of standard foot-mounted motor within the unit's AGMA rating is usable *without modification* on this All-Motor type Motoreducer. Motors with variable speed drive arrangement can be used, if desired. No "partial" motor or special shaft is required in event of motor replacement—simply use a complete motor, available for quick delivery from factory or local stocks without expensive delays.

Add to these exclusive maintenance-saving advantages the FALK "In-built" Factors, described at the right, and you have an unbeatable combination of quality, application adaptability, dependability, long-range economy, and dollar-for-dollar value. Write for Bulletin 3104.



Every FALK Motoreducer has these "In-built" Factors—

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.

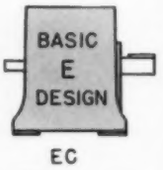
Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Sealed Housings. Dual closures and one-way vents keep oil *in,* dust and moisture *out.* Units are splash-proof, leakproof, dustproof.

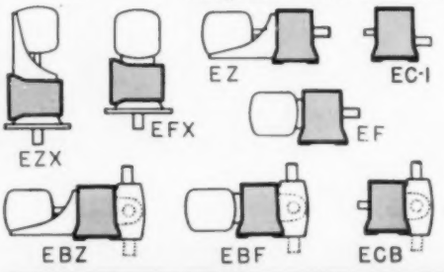
Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.



EC

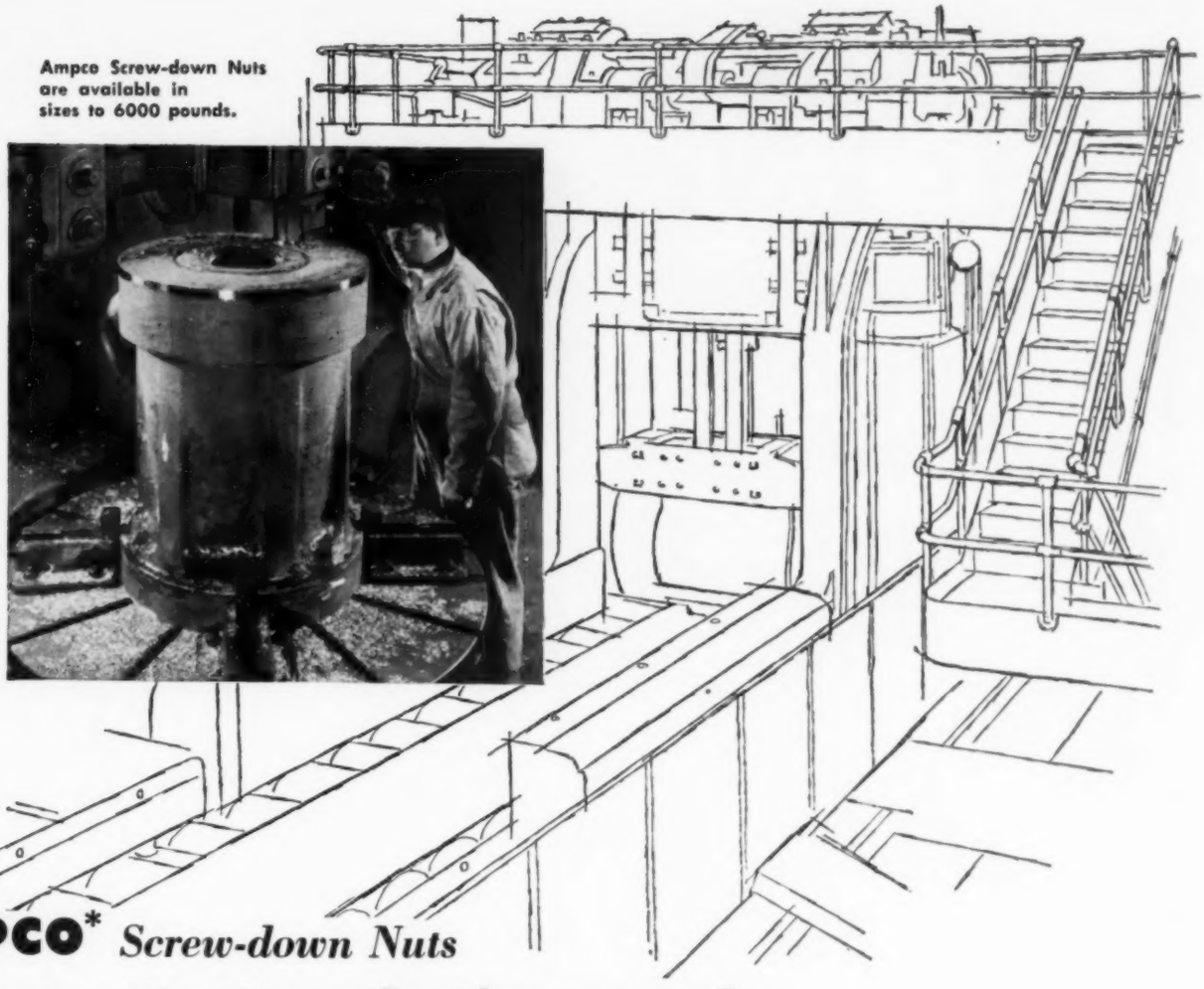
The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.



FALK ... a good name in industry

THE FALK CORPORATION · 3001 W. Canal St. · Milwaukee 8, Wis.

WRITE FOR BULLETIN 3104



Ampco Screw-down Nuts are available in sizes to 6000 pounds.

AMPCO* *Screw-down Nuts help strip mill* set production record

— handle extreme pressures to avert costly downtime and replacement

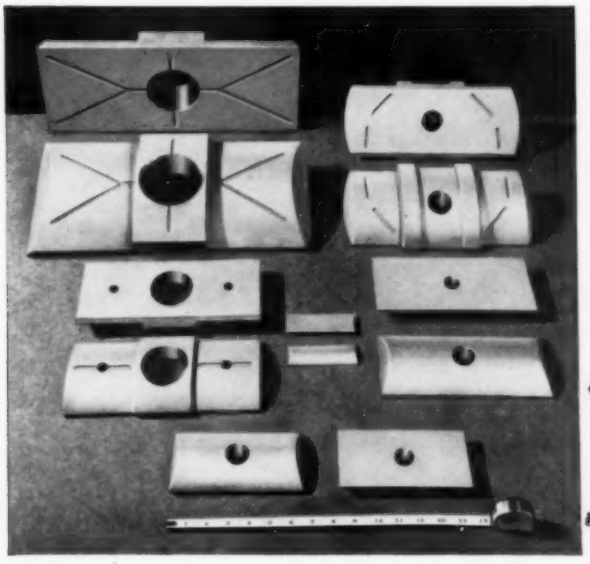
Here's where Ampco Metal's good bearing qualities, high compressive strength and ability to withstand tremendous impact and shock loads really pay off. Ampco Screw-down Nuts eliminate expensive adjustment and downtime . . . don't squash out. For example, one stand of an 80″ hot strip mill using Ampco Nuts, utilizes 4500 hp at speeds up to 282 rpm. That means "king-size" stresses and strains. Yet the records show that in spite of normal screw-down pressures of between two and three million pounds, this mill produced over three million net tons of steel in 1953. Virtually no time was lost for screw-down nut replacement or adjustment.

Ampco Screw-down Nuts are centrifugally cast to insure sound structure and good wear resistance. They're available in sizes to 6000 pounds.

And Ampco slippers help keep mills running longer, too, because they have remarkable stamina . . . real resistance to wear and punishing shock loads. Mills that set production records depend on Ampco slippers to end frequent replacement — reduce spindle wear.

Slippers are available as rough castings or "cast-to-size" — minus 0, plus 1/32″ or plus 0, minus 1/32″. Oil grooves are cast in — if you want them.

Find out how these and other Ampco products provide real dollars and cents savings in *your* mill. Contact your nearest Ampco field engineer or write us direct.



Ampco Slippers available either as rough castings or "cast-to-size." Oil grooves can be cast in.

AMPCO®

Sole producer of genuine Ampco Metal

*Reg. U. S. Pat. Off.

G-27

Ampco Metal, Inc.

DEPT. • 15-5 MILWAUKEE 46, WIS.

West Coast Plant • Burbank, California

LINK-BELT MILL BEARINGS

Series 6800 SUPER RUGGED

Cast Steel Pillow Blocks with Self-Aligning Roller Bearing

This Link-Belt "Mill Bearing" Pillow Block is unaffected by heavy loads or severe impact. Designed particularly for steel mills, mines, foundries and heavy excavating equipment, it offers many features that add up to long life efficiency under the toughest operating conditions.

If maintenance or changeovers should ultimately require a removal, no adjustment is needed in reassembly. The bearing adjusts automatically when placed in the split housing.

Easy to remove with standard tools and inspection of the complete bearing is possible by simply removing the bearing cap.

Proved on widespread equipment applications, its inherent self-aligning and pre-adjustment characteristics make the Link-Belt "Mill Bearing" superior on many industrial applications.

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INDIANA: Ft. Wayne • [illegible] • Muncie • Terre Haute
PENNSYLVANIA: Erie • Johnstown • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Wheeling
NEW JERSEY: Camden
Subsidiary: Kentucky Ball and Roller Bearing Co. • Louisville, Ky.

Bearings, Inc. 3634 Euclid Ave., Cleveland 15, Ohio

Gentlemen:

Please let me have further information on Link-Belt Mill Bearings as advertised in IRON and STEEL ENGINEER.

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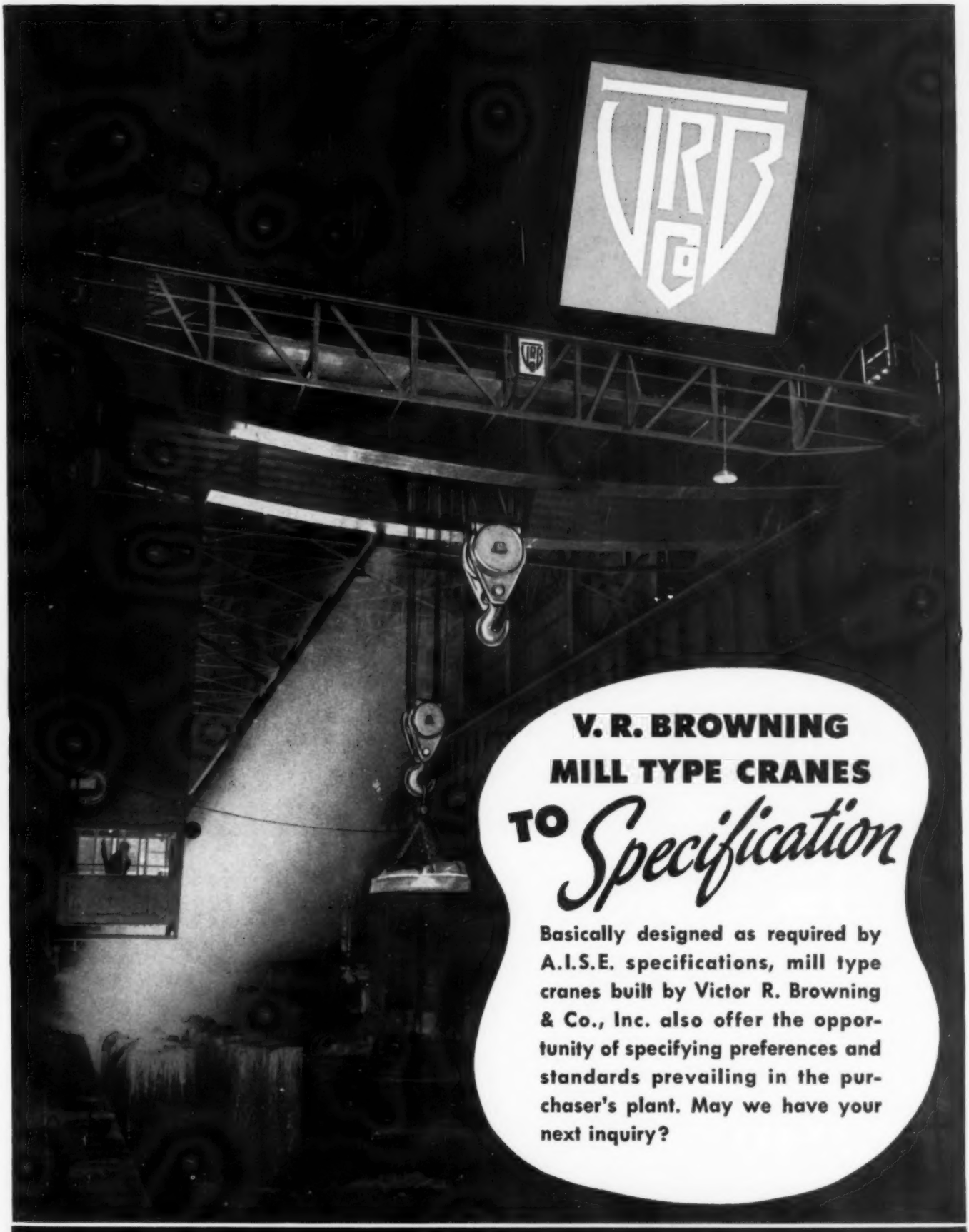
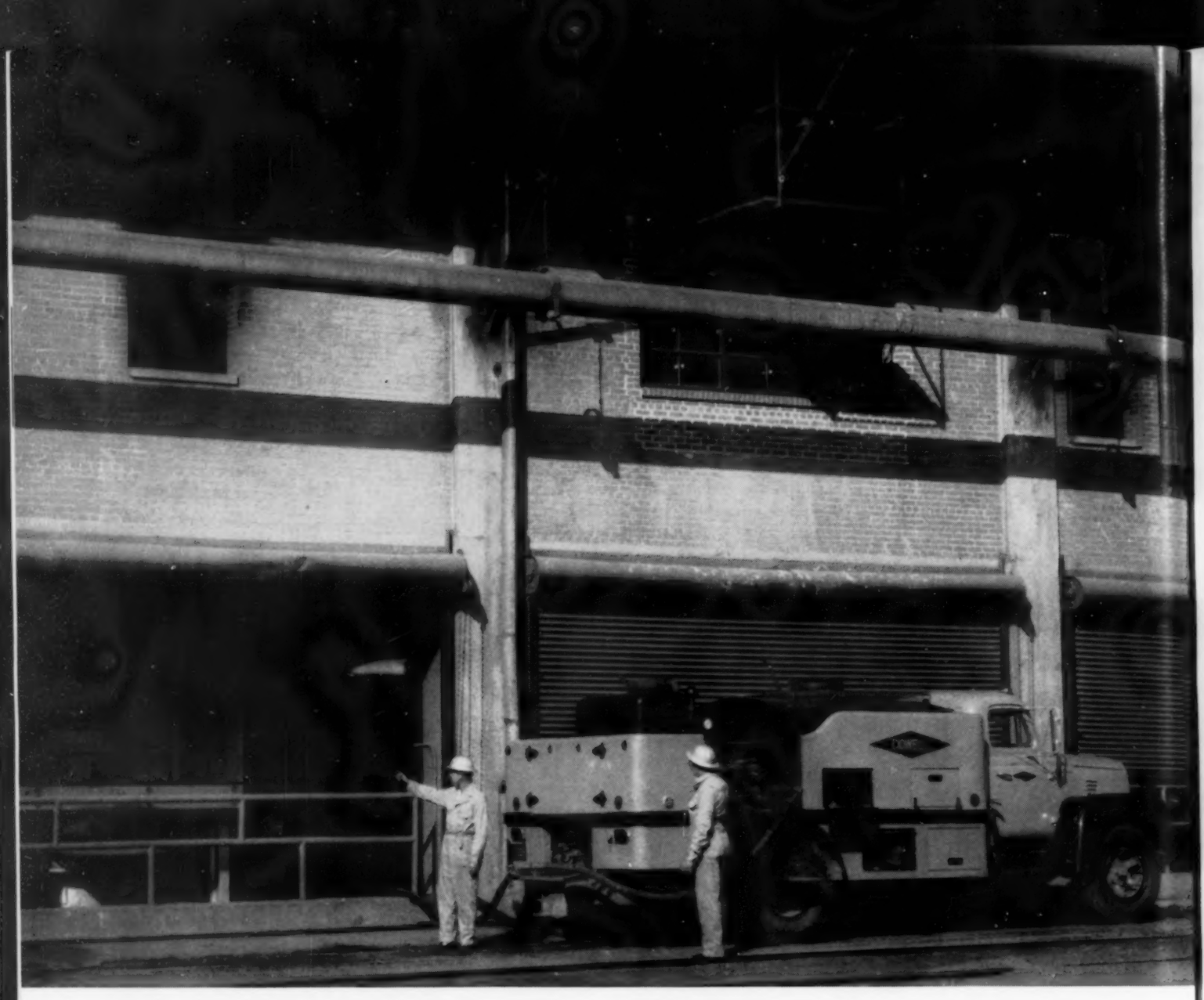

V. R. BROWNING
MILL TYPE CRANES
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes



MILL SHUTDOWN ENDED IN 3 HOURS

Shutdown ended when chemical cleaning by Dowell freed stuck valve in 54-inch gas line

Blast furnace dust in this 54-inch gas line caused a butterfly valve to stick open—forcing the shutdown of a steel plant rolling mill. An added complication was that gas flow through the line could not be interrupted. Without lessening the gas flow in the line, Dowell engineers removed the deposits chemically in just *3 hours*—permitting the mill to resume operations.

Here again, quick action by Dowell Service enabled a plant to hold costly outage to a minimum. And many times, as in this instance, Dowell engineers clean equipment without taking it out of service.

Dowell is ready to serve you any time of day or night—bringing all the equipment needed for each job into your plant. Cleaning with Dowell solvents is supplemented, where necessary, by mechanical methods—high-pressure jets and pipe line pigs.

Other steel mill equipment regularly cleaned by Dowell includes blast furnace stoves, gas washers, precipitators, open hearth checkers, boilers and condensers.

Contact the nearest Dowell office to see how Dowell chemical cleaning can help reduce costly shutdowns for you. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. E-29.

chemical cleaning service for industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

April 1

▲ The U. S. Dept. of the Interior, Bureau of Mines, reported scrap consumption during February totaled 5,361,000 gross tons in comparison with 5,416,052 tons in January. Of this 2,940,000 tons was home scrap.

April 4

▲ The AISI reports that operating rate of the steel industry for the week of April 4 is scheduled at 94.3 per cent of capacity. This is equivalent to 2,276,000 tons compared with 2,278,000 tons one week ago, and 1,622,000 tons one year ago. Index of production for the week is 141.7.

April 5

▲ The world's iron ore reserves were estimated at 84,580,000,000 metric tons or 600 years supply by a special U. N. committee. One-fourth of this is in India.

▲ Granite City Steel Co. sold $10,000,000 worth of its 18-year debentures and used proceeds to repay the remaining balance of $9,000,000 on bank loans and construction notes which were soon to be matured.

April 6

▲ Zinc was raised ½¢ to 12¢ per lb in St. Louis, the first price change in seven months.

April 7

▲ Canada has cut taxes for the 1955 fiscal year on personal income, corporations and on autos, tires and tubes.

▲ March factory employment rose to 16,265,000, an increase of 164,000 over February. However, total non-farm employment was down 69,000 from February, but a jump in farm workers brought the total employed to 60,477,000, up 539,000.

▲ Inland Steel Co.'s motor ship, the E. J. Black, opened the iron ore shipping season on the Great Lakes.

April 8

▲ Crucible Steel Co. of America announced it will redeem approximately 36,000 shares of its 5 per cent convertible preferred stock at a price of $110.7222 including accrued dividends.

▲ According to the AISI, total employment in the iron and steel industry rose to 616,400 in February against 605,100 in January with hourly payroll at $2.406 against January's $2.387. Wage earners worked an average of 40 hr per week. Total payroll in February was $255,130,000.

▲ Bethlehem Steel Co. plans to offer early in May, $191,600,000 at 3¼ per cent convertible debentures at $500 principal amount for each 25 shares held.

▲ In response to the Government's recent offer of financial aid to building atomic plants to produce electric power, the AEC announced it received proposals from three industry groups and a public power district.

April 10

▲ The F. W. Dodge Corp. reports that the total March construction contract awards in the 37 eastern states was 40 per cent ahead of March 1954 with $2,134,819,000, a new high for March.

April 11

▲ The AISI reports that operating rate of the steel industry for the week of April 11 is scheduled at 95 per cent of capacity. This is equivalent to 2,292,000 tons compared with 2,300,000 tons one week ago and 1,622,000 tons one year ago. Index of production for the week is 142.7.

▲ Shipments of finished steel products in February 1955 totaled 6,119,900 net tons, tops since October 1953, the AISI reported.

▲ On sales of $53,657,226, Allegheny Ludlum Steel Corp. reported net earnings of $2,410,906 or $1.37 per share of common stock for the first quarter of 1955 as compared with total sales of $45,614,139, net earnings of $1,063,450 or $0.58 per share in the first quarter of 1954.

April 12

▲ Government loans to small corporations jumped from $2,300,000 in January to $3,100,000 in February and to $4,700,000 in March.

April 13

▲ Imported coke briquettes from Canada, United Kingdom and Germany have been relieved of a tax of 10¢ per 100 lb, it was decided by the Treasury.

▲ Pittsburgh Steel Co. reported earnings in the first quarter of 1955 totaled $909,741 or 42¢ a common share as compared to $199,150 in the red for this period in 1954.

▲ On total sales of $25,650,448, Granite City Steel Co. reported profits for the first quarter of 1955 of $2,284,104 or $1.26 per common share. This profit was 3½ times greater than that of the like period in 1954 when profit was $638,786 or $0.28 per common share on sales of $16,482,859.

▲ The British Government released 45,000 tons of copper stocks for sale to help ease the world shortage of the metal.

April 15

▲ Republic Steel Corp. reported consolidated net income of $18,192,265 or $2.38 per share of common stock for the first quarter of 1955 as compared with $11,079,012 or $1.79 per share a year ago. Sales for first quarter totaled $263,273,372 compared with $216,469,708 last year.

▲ Barium Steel Corp. announced net sales for the year ending December 31, 1954 of $53,484,603 resulting in a net loss of $441,212 as compared with sales of $89,719,175 and a net profit of $2,321,140 for the previous year.

▲ Acme Steel Co. reported sales in the first quarter of 1955 totaled $24,780,022 with earnings after taxes of $1,541,723 or $0.78 per common share as compared with the previous year's sales of $17,116,420 and net earnings of $644,963 or $0.32 per common share for the like period in 1954.

▲ Kaiser Steel Corp. took an option to purchase all the real estate and mining facilities of St. Louis, Rocky Mountain and Pacific Co. at Raton, N. M. It included 202,000 acres of land and coal rights on 326,000 additional acres.

▲ Washington Steel Corp. registered 30,000 shares ($15,000,000) of $50 par convertible preferred stock with the Securities and Exchange Commission.

April 18

▲ The President's Council of Economic Advisers estimated the national production of goods and services at a yearly rate of $369,000,000,000 in the first quarter of 1955.

▲ A sum of $64,000,000 will be invested by the Government for tools and production facilities required to build ship turbines.

▲ The AISI reports that operating rate of the steel industry for the week of April 18 is scheduled at 95.5 per cent of capacity. This is equivalent to 2,305,000 tons compared with 2,284,000 tons one week ago and 1,636,000 tons one year ago. Index of production for the week is 143.5.

▲ Colorado Fuel and Iron Corp. reported net earnings for the first quarter of 1955 at $2,929,894 or $1.04 per share on common stock compared to a net profit of $771,456 or $0.20 per common share for the like period in 1954.

▲ The Aluminum Association reported aluminum production in March 1955 at 260,543,479 lb as compared with 232,472,999 lb in February and 244,678,349 in March 1954.

April 19

▲ The sale of all Mackintosh-Hemphill assets to E. W. Bliss Co., Canton, Ohio was approved by its stockholders.

▲ The ARCI announced deliveries of new domestic freight cars in March totaled 2833 compared with 2422 in February and 4823 in March 1954. Orders for 2156 cars were placed in March leaving a backlog of cars on order as of April 1 totaling 17,974.

April 20

▲ Crucible Steel Co. of America reported net sales during the first quarter of 1955 were $50,943,010 and net income was $2,248,896 or $2.02 per common share. In the like period of 1954, net sales were $43,440,380, net income was $529,926 or $0.25 per share.

▲ Sharon Steel Corp. reported sales amounting to $39,933,539 and net income of $2,229,271 or $2.03 a share for the first 1955 quarter in comparison with $23,913,260 and net income of $70,716 or $0.06 a share for the like period in 1954.

April 21

▲ Expansion of facilities by Republic Steel Corp. at an estimated $35,000,000 was announced.

▲ Kaiser Steel Corp. reported a net income of $3,729,311 on total sales of $88,345,768 for the nine months ending March 31, 1955 as compared with net income of $13,463,704 on total sales of $99,513,524 for the same period in the previous year.

▲ Armco Steel Corp. announced the authorization by stockholders of additional shares of stock and stated that a 2-for-1 stock split would take place as soon as possible.

▲ Production of soft coal in the U. S. will gain about 12½ per cent over last year's 395,000,000 tons according to the Pittsburgh Consolidated Coal Co.

▲ Alcoa reported total sales of $197,716,103 with a net profit of $17,074,167 or $1.63 per common share for the first 1955 quarter in comparison with sales of $163,156,190, net profit of $8,372,105 or $0.78 per common share last year.

April 22

▲ The old Apollo Steel Co., which has been inactive for almost four years, has been purchased by a Pittsburgh group and will be converted into a steel fabricating plant.

▲ General Motors sales spurted to $3,101,000,000 for the first quarter of 1955 with net profits rising to $309,000,000 equal to $3.43 per common share in comparison with sales for this period in the previous year amounting to $2,410,000,000 and net profits of $189,000,000 or $2.13 per common share.

April 25

▲ Jones and Laughlin Steel Corp. reported 1955's first quarter sales and revenues totaled $151,962,000 leaving a net income of $9,642,000 or $1.50 per common share in comparison with the corresponding period in 1954 with total sales of $127,880,000, net income of $5,821,000 or 88¢ per common share.

▲ The AISI reports that operating rate of the steel industry for the week of April 25 is scheduled at 96.0 per cent of capacity. This is equivalent to 2,316,000 tons compared with 2,284,000 tons one week ago and 1,637,000 tons one year ago. Index of production for the week is 144.2.

▲ Armco announced 1955's first quarter sales of $154,774,000 with a net income of $12,689,123 or $2.41 per common share in comparison with 1954's first quarter showing total sales of $131,346,000 and net income of $9,137,226 equal to $1.75 per common share.

April 26

▲ The AISC reports March bookings of fabricated structural steel amounted to 285,434 tons compared with 233,885 tons in February and 193,509 tons in March 1954. Shipments in March totaled 227,789 tons leaving a backlog of work ahead as of March 31 of 1,391,756 tons.

▲ Youngstown Sheet and Tube Co. reported earnings of $7,975,488 or $2.37 a share on income of $139,069,701 during the first three months of 1955 against earnings of $2,989,478 or 89¢ a share on sales of $105,863,413 during the corresponding period in 1954.

▲ U. S. Steel Corp.'s first quarter 1955 operations showed revenues of $873,327,061, a net profit of $72,652,402 or $2.49 per common share compared with the corresponding period in 1954 with revenues of $830,826,211, a net profit of $44,830,376 or $1.48 per common share.

▲ Pittsburgh Coke and Chemical Co. reported 1955 first quarter revenues of $11,689,000 and net income of $577,000 or $0.51 per common share. This compares with the corresponding period in 1954 with total sales of $7,709,000 and a net income of $132,000 or $0.09 per common share.

April 27

▲ Inland Steel Co. reported net income for the first quarter of 1955 at $10,432,755 or $1.95 a share on sales of $148,812,711 compared with 1954's first quarter's net income of $9,463,250 or $1.92 a share on sales of $137,590,737.

▲ National Steel Corp. announced sales in the first quarter of 1955 amounted to $150,807,501 with net earnings of $11,203,461 equal to $1.52 a share compared with sales in the first quarter of 1954 amounting to $130,445, 704 and net earnings of $6,420,225 equal to $0.87 a share.

April 28

▲ CIO Steelworkers notified the steel companies that pay increases will be asked in contract negotiations.

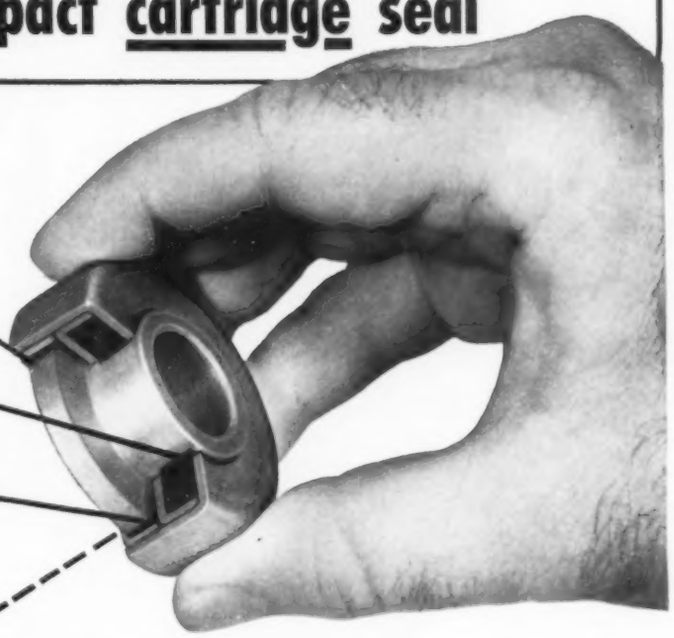
▲ Interlake Iron Corp. announced net sales for the first quarter of 1955 reached $22,147,449, the highest in the company's history for any quarter, and net income of $1,597,163 or $0.82 a share. Last year's figures for this period showed net sales of $15,433,582, net income of $578,129 or $0.30 a share.

April 29

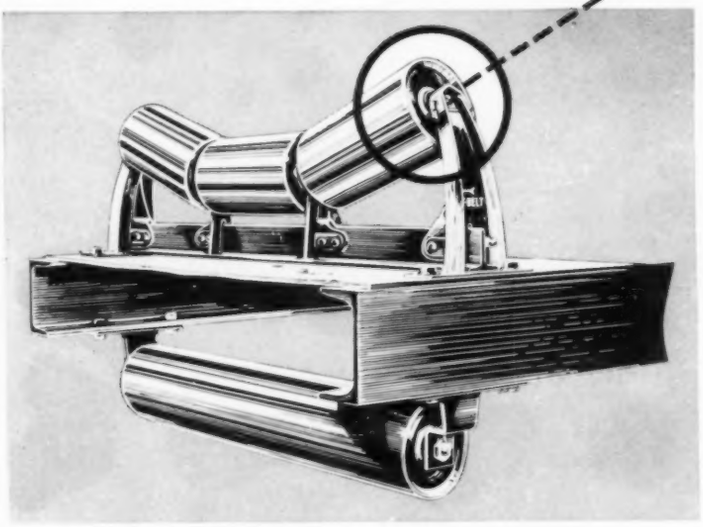
▲ Bethlehem Steel Co. reported record first quarter earnings of $35,313,262 or $3.51 a share on billings of $451,088,588 compared with last year's figures of $27,802,938 or $2.73 a share and $445,110,162.

▲ Jones and Laughlin Steel Corp. announced a $50,000,000 expansion program at its Aliquippa, Pa. and its Pittsburgh Works.

For longer idler life . . . here's 3-WAY protection in ONE simple, compact cartridge seal



1. Labyrinth seal
2. Contact seal
3. Clearances Grease Filled



THE effectiveness of Link-Belt cartridge grease seals in protecting belt conveyor idler bearings is matched by no other in industry. Besides the normal high efficiency of Link-Belt's labyrinth and contact seals . . . grease within the labyrinth further prevents entry of dirt or other particles. This cartridge (see above cutaway) is one integral unit—no springs, no loose washers . . . no possibility of metal-to-metal contact. From shaft to shell—bearings, fittings, rolls, frames, even hex nuts are designed for long, trouble-free life.

Also important, you can always find the *right* idler in industry's most comprehensive line—over 500 idlers in 34 types, built in a broad range of roll diameters and belt widths with matching return idlers. Ask your Link-Belt sales representative or authorized stock-carrying distributor for 48-page Book 2416, which covers this broad line thoroughly.

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Continuous service for maximum volume per lineal foot of belt.

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Industry News...

DIRECTORS APPROVE $35,000,000 APPROPRIATION FOR NEW FACILITIES AT REPUBLIC STEEL PLANTS

▲ Appropriations totaling $35,000,000 for new equipment and facilities have been approved by directors of Republic Steel Corp.

Included is equipment for Republic's recently announced program for the production of hot and cold rolled steel sheets at the Gadsden, Ala., plant. Republic's entry into the flat-rolled business in the South is geared to meet the growing demands of the steel fabricators in this booming industrial section. Also included is the previously announced by-product coke oven battery at the Massillon, Ohio, steel plant.

Other major projects to be undertaken as a result of the directors' action include:

Plastic Pipe—Installation of equipment at Republic's Pressed Steel Division, Cleveland, to produce over 650,000 ft per month of plastic pipe in a variety of sizes. Republic presently produces plastic pipe at Magnolia, Ark.

Rehabilitation of Youngstown, Ohio Benzol Plant—Completion of a program started in 1950 to rehabilitate the by-products and Benzol plant is authorized.

Plastic Coated Steel Pipe—Equipment to permit steel pipe from ¾ in. to 4 in. diameter to be coated with plastics for special uses where unusual corrosion resistance and high strength is desired. This equipment will be installed at Republic's Youngstown plant. The plastic coated steel pipe will be an entirely new product of the company.

Additional Silicon Strip Annealing Facilities—Facilities will be installed at Republic's Warren, Ohio plant to permit 1,500 tons per month increased production of silicon strip, widely used in electric motors and other electric products.

Equipment for Expanding Mining in Northern Michigan—The Genesee ore body adjacent to Republic's Tobin Mine, Crystal Falls, Mich. will be opened up making available at least 1,500,000 tons of underground ore.

Several dozen other projects will be undertaken at various Republic plants with the funds appropriated by the directors including the modernization of two blast furnace stoves and the installation of such varied equipment as electric transformers, motor generator sets, continuous coal mining machines, a 225-ton ladle crane, bar turning machines, Nylok nut machines, materials handling equipment, annealing equipment, locomotive cranes, laboratory instruments and trucks.

This single list of appropriations exceeds substantially the entire amount spent during 1954 for similar purposes, according to C. M. White, President.

KAISER TO PURCHASE BASALT ROCK DIVISION

▲ Kaiser Steel Corp. will purchase the Steel Division of Basalt Rock Company, Inc., the largest pipe fabricator in the West, according to an announcement made by Jack L. Ashby, vice-president and general manager of Kaiser Steel, and A. G. Streblow, president of Basalt Rock. The transaction is subject to approval by Basalt stockholders.

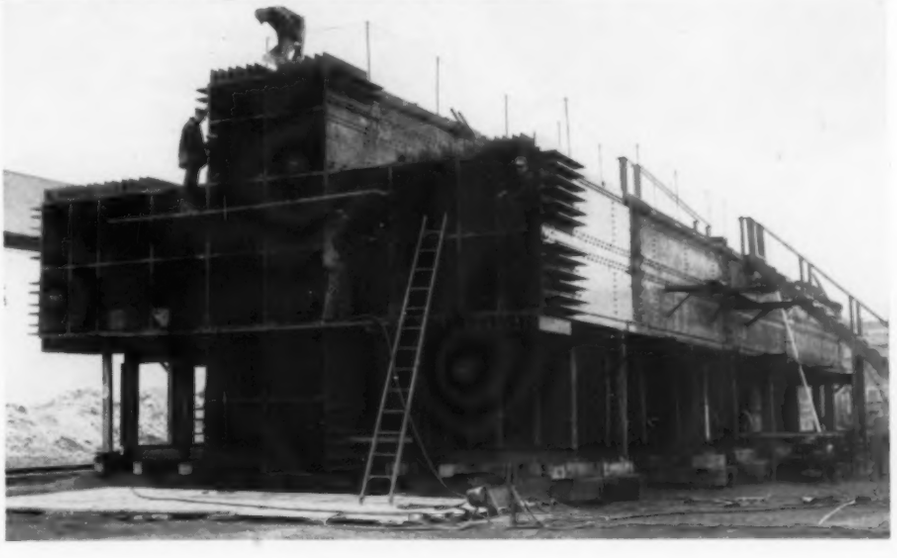
The facilities consist of two modern plants, one located at Napa, Calif., near San Francisco, and the other at Fontana, near Los Angeles. The plants produce large diameter expanded steel line pipe, medium diameter electric resistance weld pipe, large diameter steel reinforced concrete pipe, and a variety of fabricated steel products.

The other operations of Basalt Rock Company, Inc., primarily in the fields of concrete aggregates, Basalite and related building materials, are not affected by the purchase.

Production at the two plants will continue uninterrupted. Ernest Illsley, vice-president of Basalt Rock Company, Inc., and a veteran of nearly 25 years with Basalt, will join Kaiser Steel as manager of both the Napa and Fontana plants.

BRIDGE TOWERS READIED AT AMBRIDGE PLANT

Mackinac Bridge Authority members and design engineers gathered with newsmen and steel officials recently at the Ambridge, Pa., plant of U. S. Steel's American Bridge Division for a first-hand look at the towers for the world's longest suspension bridge now in the fabrication stage. This bridge is a five-mile span which will link Michigan's upper and lower peninsula. Bridge towers are now being assembled in the American Bridge plant. After sectional assembly the 552 ft towers are disassembled for shipment to Mackinac Straits for erection. The towers will each contain 7000 tons of structural steel.



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FREE CATALOG: Send coupon today!

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TAYLOR MADE A GREAT NAME IN *Chain* SINCE 1873

E. W. BLISS CO. ACQUIRES MACKINTOSH-HEMPHILL

▲ Stockholders of the Mackintosh-Hemphill Co. approved on April 18 the sale of the company's assets to the E. W. Bliss Co. Mackintosh-Hemphill, which now becomes a division of Bliss, will continue to operate its plants in Pittsburgh and Midland, Pa. No changes in operations or personnel are contemplated.

Bliss acquires the business, goodwill, properties and assets for common stock of Bliss on the basis of nine of its shares for each ten shares of the common stock of Mackintosh-Hemphill.

"This move," explained Howard U. Herrick, President of E. W. Bliss Co., "is the natural, logical result of many years of common business interests and warm associations between Bliss and Mackintosh-Hemphill. In fact, the interests of Mackintosh-Hemphill and those of our Rolling Mill Division have been so closely allied that a consolidation of working strength was recognized as clearly desirable."

TO BUILD BATTERY OF NEW COKE OVENS

▲ A $10,000,000 expenditure for a new battery of coke ovens and auxiliary facilities is scheduled for the Chicago, Ill., plant of Interlake Iron Corp.

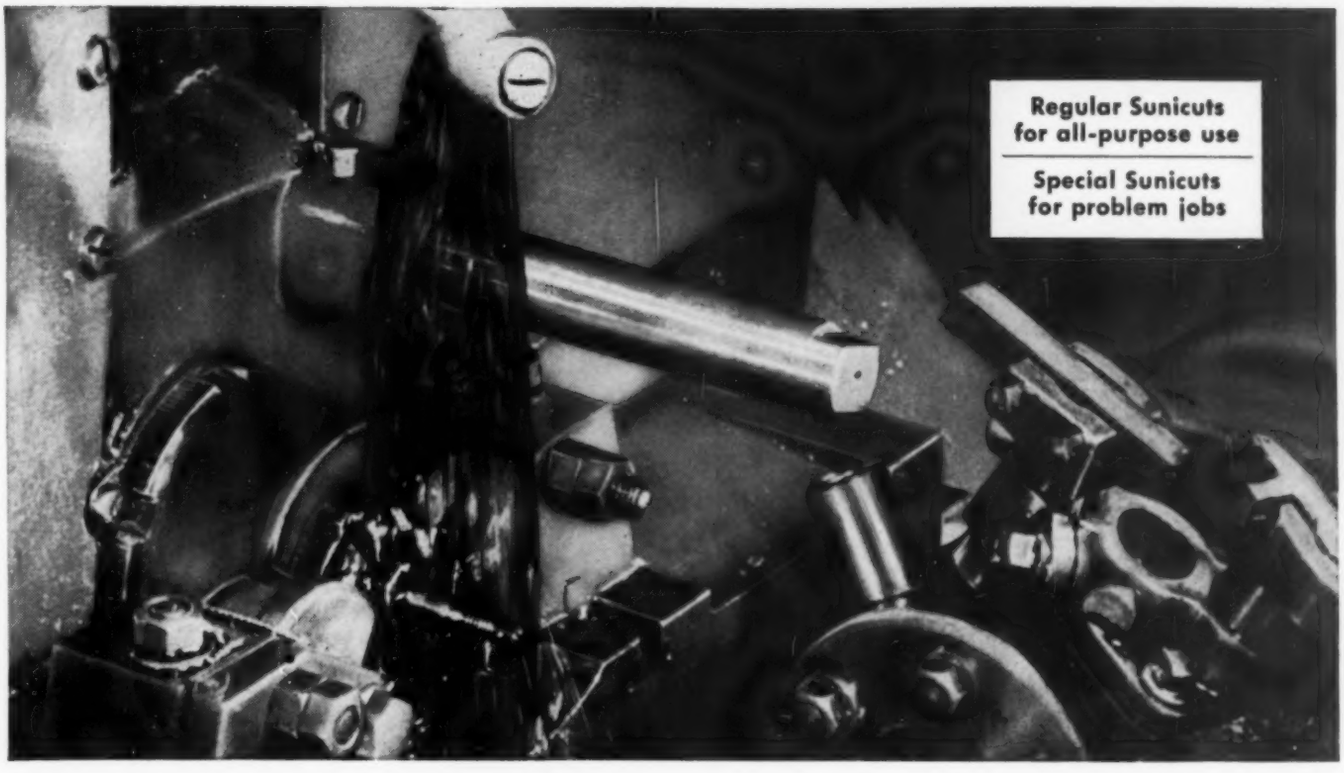
The new battery will include 50 ovens and will replace units built in 1912. The improvement is the most important made in Chicago by the company since 1953, when a new blast furnace was built, replacing a smaller unit.

Prime contracts for the construction work are being let to the Wilputte Coke Oven Division of Allied Chemical and Dye Corp. It is expected that the work will be finished in the summer of 1956.

KAISER WILL INSTALL ALL-ALUMINUM CRANES

▲ The nation's first major large-span, all-aluminum, welded mill-type cranes will be installed at Kaiser Aluminum and Chemical Corp.'s new rolling mill near Ravenswood, W. Va.

Seven 105-ft span overhead cranes have been ordered from the Cleve-



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Today's Sunicut cutting oils are the result of years of research and on-the-job testing. And they're versatile, too. In many plants *all* screw machine jobs are being handled by a single Sunicut grade.

For the problem jobs, Sun makes a wide variety of special Sunicut oils, each designed to do the job better.

Your Sun representative has the practical know-how to analyze *your* problems. Working with Sun's experienced engineering staff, he's ready to help you pick the Sunicut oil that will give you the tolerances and finishes you want.

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land Crane & Engineering Co. Specifically, the order calls for one aluminum crane with a 100-ton capacity, three with 50 tons each, and three with 10-ton capacities.

The all-aluminum cranes will be of conventional design, and control, except for the structural material involved.

The aluminum components will include the girders, saddles, trucks, diaphragms, catwalks, web, cover plates, trolleys, control cabs, collector rails and shoes.

Construction of the cranes complies with standards established by the American Standards Association, the Association of Iron & Steel Engineers, and the safety codes of W. Va.

Kaiser Aluminum officials emphasize the use of aluminum for the cranes was decided upon for economic and engineering advantages. Their studies indicate long-span, high-capacity mill cranes operating over long building bays would be less costly overall than comparable steel cranes. By using the lighter aluminum, a weight savings of approximately 50 per cent will be gained in the crane girders.

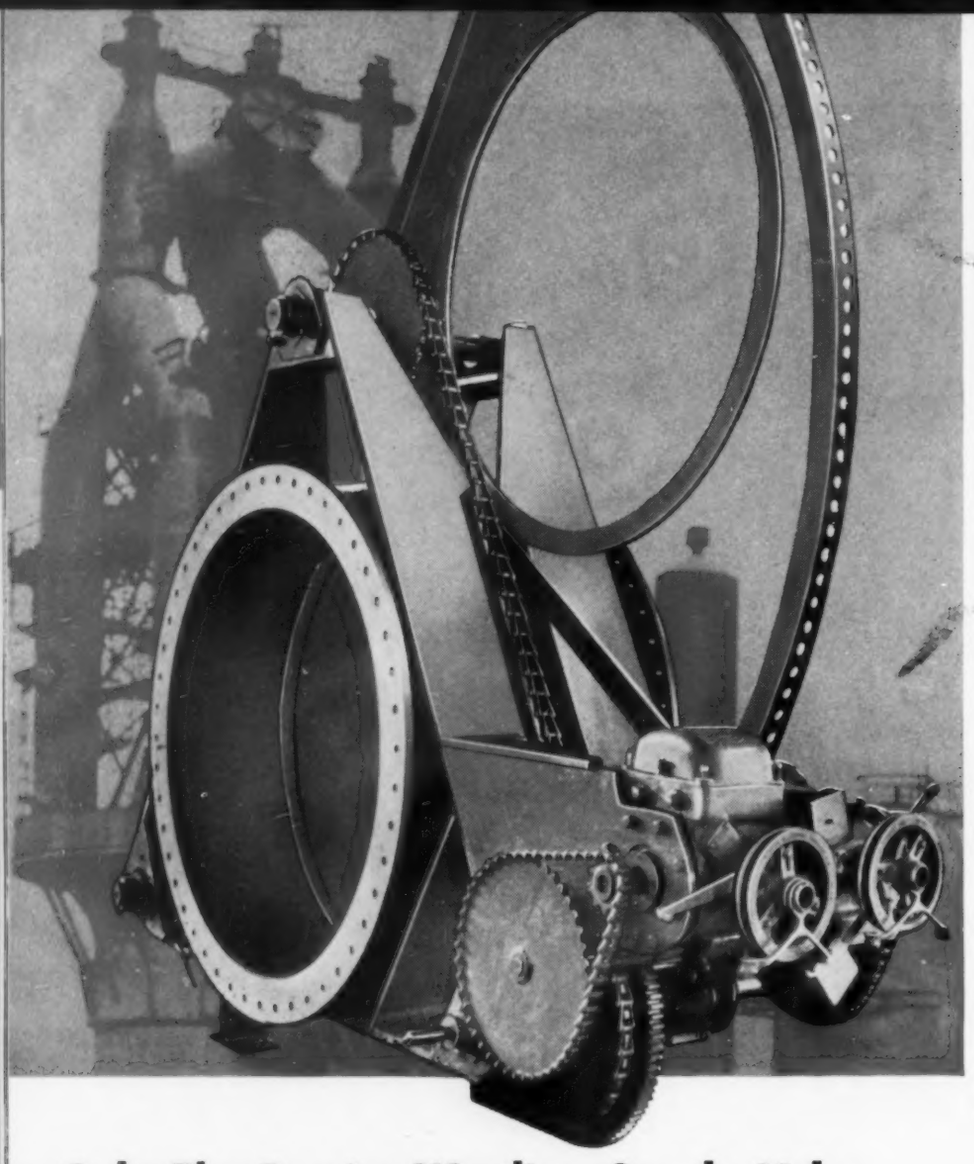
Total weight reduction will be about 35 per cent resulting in cumulative savings throughout the cranes —proportional reductions in power requirements, motor sizes, shafts, bearings, gear boxes, etc.

The lighter wheel loads should decrease vibration and pounding as the cranes cross open joints in the craneways. The corrosion resistance of the aluminum will assure structural integrity with a minimum of maintenance.

RITTER ENGINEERING NAMED PARKER AGENT

▲ Ritter Engineering Co., Pittsburgh, Pa., is now a distributor for Parker tube and pipe fittings and tube-working tools, according to an announcement of D. A. Cameron, industrial sales manager of the Parker Appliance Co., Cleveland, Ohio.

Wayne G. Ritter, head of the distributing firm, reports stocks are being maintained for prompt servicing of fitting requirements throughout western Pa., and upper W. Va. His firm is also handling Hoze-lok reusable hose fittings, accumulators, directional valves, check valves and other Parker hydraulic components.



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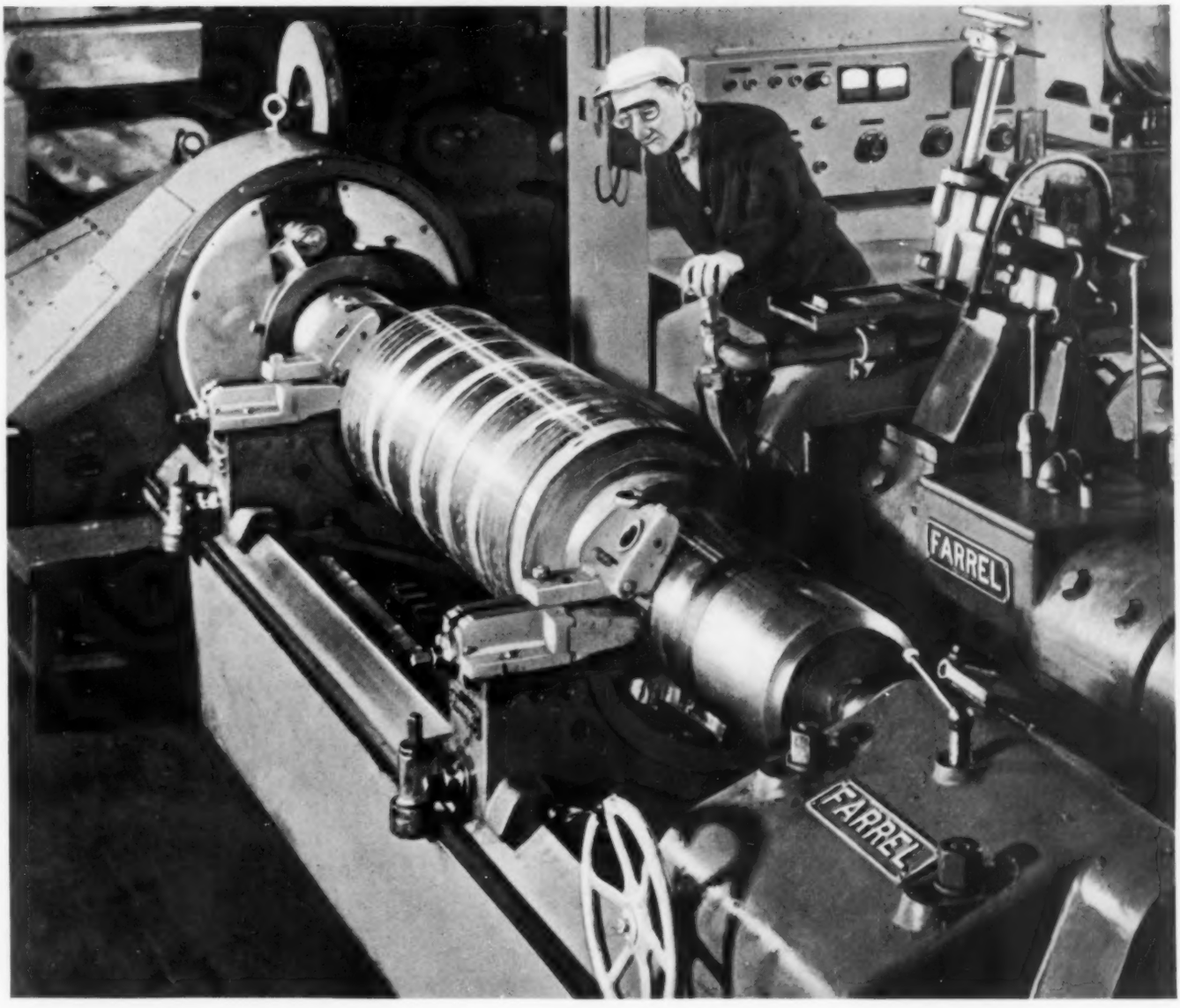

FARREL H-D ROLL GRINDERS TAKE AWAY THE GUESSWORK IN U. S. STEEL PLANT

Forged steel rolls produced at the Homestead Forgings Division of United States Steel Corporation are ground on Farrel heavy-duty roll grinders. According to the men who run these machines, Farrel roll grinders are accurate and easy to handle, and take away the guesswork from this important operation.

Farrel heavy-duty roll grinders are equally suited for either heavy roughing or fine finishing. Many automatic features simplify both setup and operation. Setting-up time is held to a minimum.

Farrel machines grind straight, convex or concave contours to exact symmetry and accuracy. Contributing to grinding accuracy is the Farrel automatic crowning and concaving device. Easily and quickly set, it requires no manipulation during operation. The same setting produces exactly the same curvature and permits fixed, uniform and easily controlled accuracy of contour in all rolls.

A Farrel heavy-duty roll grinder can take the guesswork out of your grinding too. Write today for Bulletin No. 115, which describes this machine in detail.

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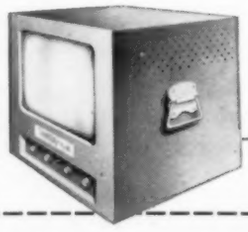

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For technical assistance, the distributor has available the services of W. O. Murray, Parker district manager in Pittsburgh.

GE TO BUILD GENERATOR SETS FOR MEXICAN FIRM

▲ The manufacture by General Electric Co. of two 16,000 kw combustion gas turbine-generator sets for a Mexican industrial firm was announced by John P. Keller, general manager of GE's gas turbine department.

The sets will have a higher rating than any yet manufactured in the Western Hemisphere.

Scheduled for shipment to Planta Electrica of Groupo Industrial in Monterrey, Mexico in 1956, the two simple-cycle, single-shaft sets will be installed adjacent to the Hojalata y Lamina steel mill. Natural gas will be used as fuel.

It is expected that eventually the heat in the exhaust gas of the turbines will be used to generate process steam in heat recovery boilers. Generation of both electric power and steam by each set will result in a highly efficient installation.

START CONSTRUCTION ON NEW IRON FOUNDRY

▲ The Chambersburg Engineering Co. has begun construction of a large iron foundry to replace the existing facilities which have been in operation since 1906. Production is expected to be shifted to the new building in October of this year without any interruption in schedules.

The monthly capacity of the new foundry will be 750 tons of castings, matching the output of the present foundry.

WORK BEGINS ON NEW TIN MILL FACILITIES

▲ Construction of the Youngstown Sheet and Tube Co.'s large new tin mill facilities at Indiana Harbor is underway with the driving of foundation piles. Production of the new mill will double the capacity of the present electrolytic facilities.

The new tin mill will require between 300 and 400 additional employees and will consist of seven buildings to be constructed on 88 acres of Youngstown property south-

west of the community of Marktown, a sub-division of East Chicago. The facilities will include a cleaning and annealing building, a temper mill and coil storage building, a preparation line building, an electrolytic tinning line building, three shear lines, an assorting room and a warehouse and shipping building.

A feature of the new tin mill will be a four-high, two stand temper mill with a capacity speed of more than a mile a minute. The annealing furnaces will be the new, radiant-tube, portable-cover type, similar to the ones in the company's recently completed cold reduced sheet mill.

Steel for processing through the new tin mill facilities will come from the five-stand tinplate reduction mill at the present tin mill and the four-stand mill at the cold reduced sheet mill.

ANNOUNCES LARGE SCALE EXPANSION PROGRAM

▲ A multi-million dollar transformer and circuit breaker manufacturing expansion program at Allis-Chalmers Manufacturing Co., Terre Haute, Ind., and Gadsden, Ala., plants was announced.

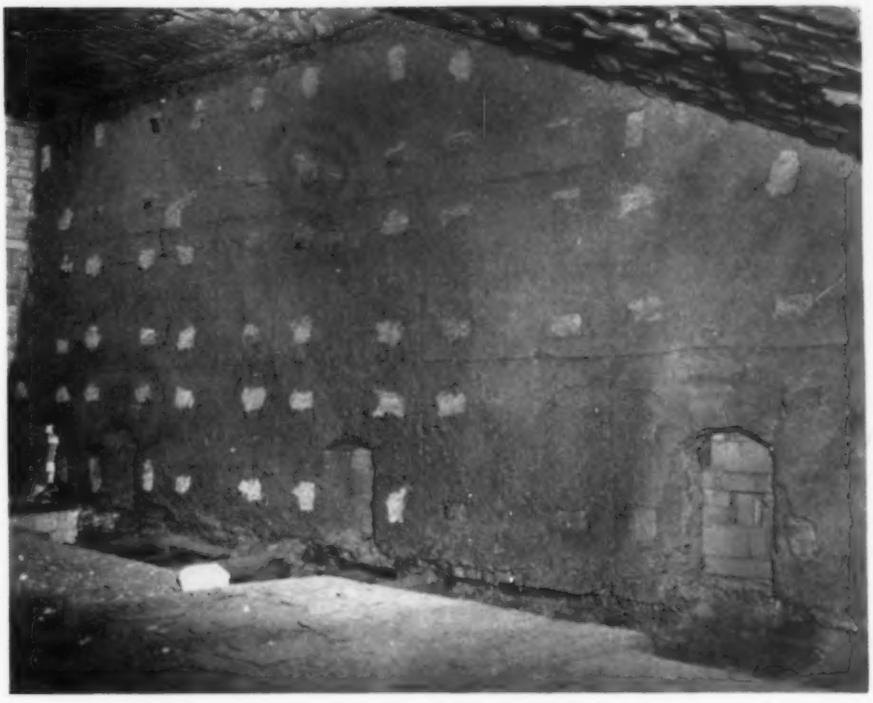
Large high voltage power transformers and high voltage heavy current circuit breakers will be manufactured at the Terre Haute Works, and distribution transformers at the Gadsden Works.

Plans call for the erection of a new 114,000-sq ft building at Terre Haute. Estimated cost of the new plant, tooling and landscaping is approximately 9½ million dollars. This is in addition to 4½ million dollars spent on transformer facilities at Terre Haute in 1954 and brings the total Allis-Chalmers investment in the plant to approximately 25 million dollars.

The new facilities are expected to be in operation in 18 months. One bay in the new 240 by 480-ft building will be 80 ft high enabling manufacture of the largest type transformers and breakers. This bay will eventually utilize two cranes 65 ft above the floor. The combined cranes will be capable of handling transformers weighing 400 tons.

The Terre Haute Works now assembles switchgear, fabricates transformer tanks, and is manufacturing compressors for the J-65 Curtiss-Wright turbo jet engine.

A RAMTITE INSTALLATION



IN A SLAB HEATING FURNACE

...at United States Steel Corp., South Works, Chicago, Illinois, has paid for itself several times over during five years of economical, dependable service with maintenance cost less than $50.00.

Some of the many economies possible with the use of Ramtite Refractory Products in steel mill furnaces are: longer life, ease of installation, sturdier construction, less tendency to spall, improved furnace condition and lower inventory. Can you afford NOT to use Ramtite.

RAMTITE IS OUR BUSINESS — NOT OUR SIDELINE. Over 35 years experience in Plastic and Castable Refractories qualifies us as experts in design, construction and application of these products.

Send in the coupon for bulletins or Steel Plant Catalog — or call Ramtite local office for additional information.

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This is another in a series of advertisements depicting the ways in which Ramtite Refractories can be of service in the steel industry.

TROUBLED WITH "SLIPPER-TYPE" COUPLING FAILURES?
CONVERT TO
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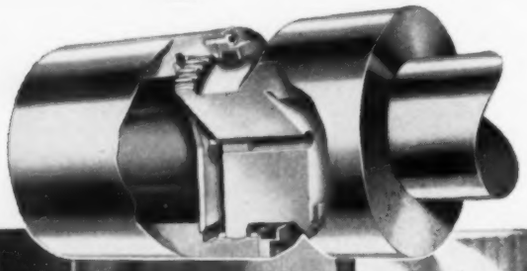

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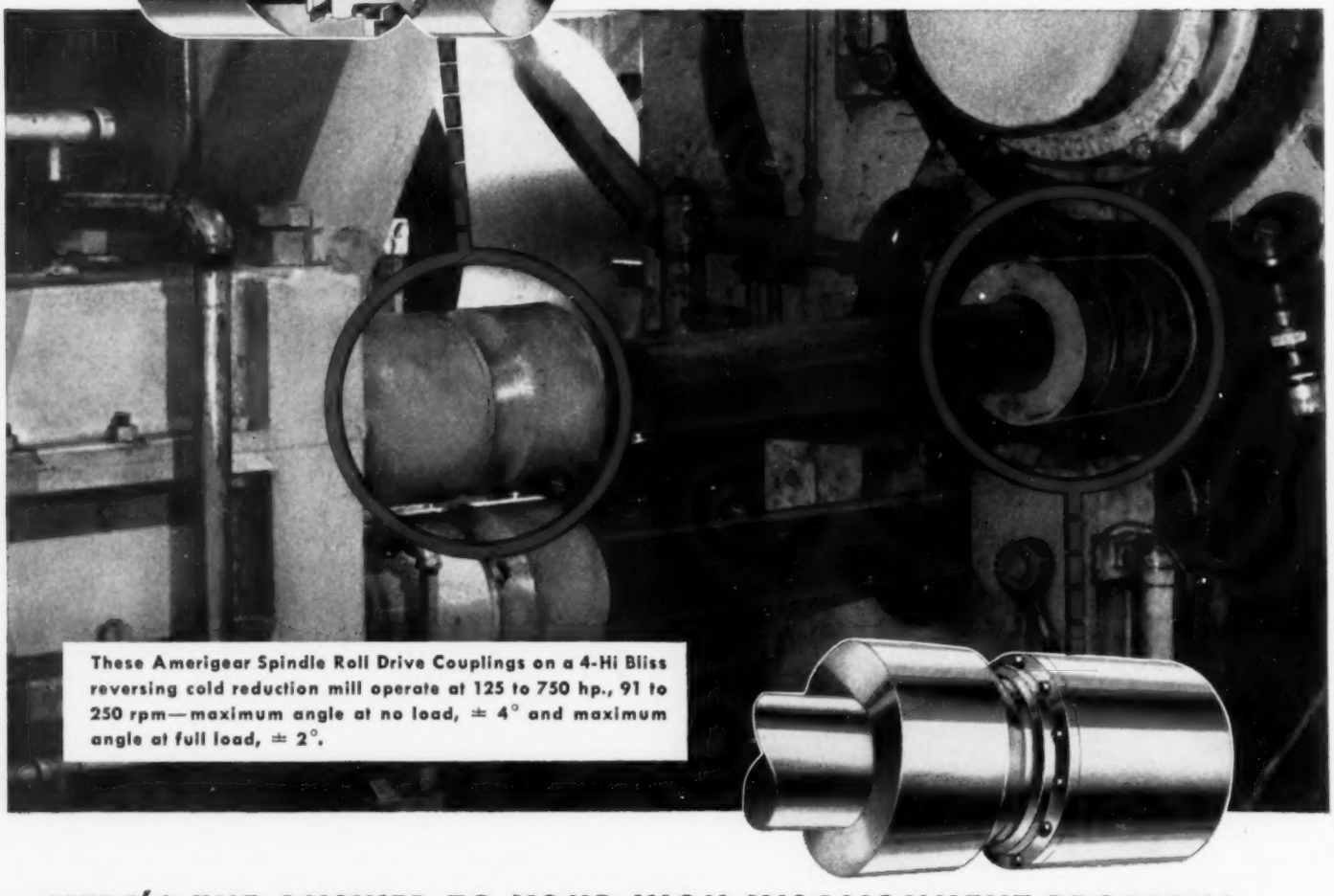

These Amerigear Spindle Roll Drive Couplings on a 4-Hi Bliss reversing cold reduction mill operate at 125 to 750 hp., 91 to 250 rpm—maximum angle at no load, ± 4° and maximum angle at full load, ± 2°.

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Amerigear's Fully-Crowned Tooth Form concentrates the load towards the center of the tooth, eliminates tooth end and tip loading. This permits an extremely high degree of angular and lateral misalignment—up to ± 9° per engagement—with no wear or loss of power.

And By Accomodating For Roll Wear and varying distances between roll centers, Amerigear Spindle Roll Drive Couplings keep your maintenance expenses to a minimum. That's because they're precision-manufactured to transmit power to the rolls smoothly and continuously . . . even after repeated roll grinding . . . *without maintenance.*

Downtime Goes Down, Too because engaging roll end teeth are specially designed for quick assembly and disassembly. So the next time you're in need of flexible couplings for your ferrous or non-ferrous rolling mills, convert to Amerigear — a highly engineered solution to your every high misalignment problem.

Amerigear Engineers are ready to help you design improved operating efficiency into heavy presses, slitters, cranes, reels or other steel mill equipment. Write for Catalog 501 and Bulletin 1052, or attach coupon below to your letterhead.

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AMERICAN FLEXIBLE COUPLING COMPANY
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CANADIAN ZURN ENGINEERING, LTD.
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AMERICAN FLEXIBLE COUPLING COMPANY
ERIE, PA., U. S. A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....
Please attach to your business letterhead.

Dept. ISE-999

Manufacture of distribution transformers is scheduled to begin late this year at Gadsden.

CONSTRUCTION UNDERWAY ON NEW SELAS PLANT

▲ Work has started on a new $1,000,000 plant for the Selas Corp. of America. The new plant is being constructed on an eleven-acre site at Dresher, Pa., twenty-two miles north of downtown Philadelphia.

All research and development activities will be concentrated in a single building specifically designed to provide coordinated laboratory facilities. Production facilities will be arranged for maximum efficiency and versatility in a second building. A third building will house administrative offices.

TO BUILD COKE OVENS FOR SOUTHERN FIRM

▲ A contract to build a battery of 30 chemical-recovery coke ovens has been awarded to Koppers Co., Inc. by the U. S. Pipe and Foundry Co. of Birmingham, Ala., it was announced by G. M. Carvlin, vice president and general manager of Koppers Engineering and Construction Division.

This is the second such contract to be awarded by this company to Koppers, who installed a similar battery for them in 1952. When this second battery is completed, U. S. Pipe and Foundry will have a total of 180 ovens capable of producing 3,500 tons of coke per day.

INLAND BEGINS DREDGING PROJECT TO EXPOSE ORE

▲ The start of a five-year dredging project which will precede actual mining of iron ore from the Inland Steel Co.'s ore property near Atikokan in western Ontario, has been announced.

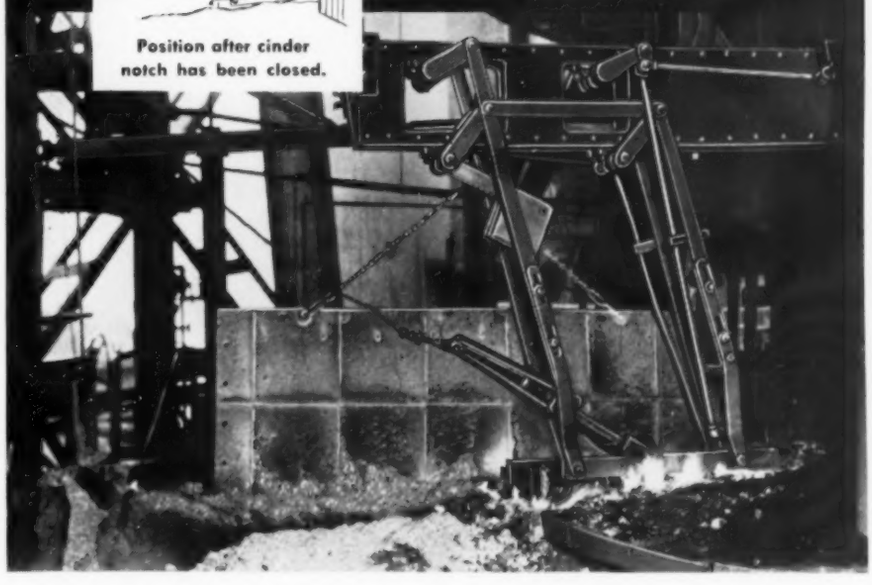
Two giant dredges, assembled at the site by Construction Aggregates Corp. and to be operated by that Chicago firm as contractor for the steel company, will run night and day until some time in 1960, removing an estimated 160,000,000 cu yd of glacial silt overlying the ore at the bottom of the Falls Bay arm of Steep Rock Lake.

Both open-pit and shaft mining will be done at the property. Driving

Bailey

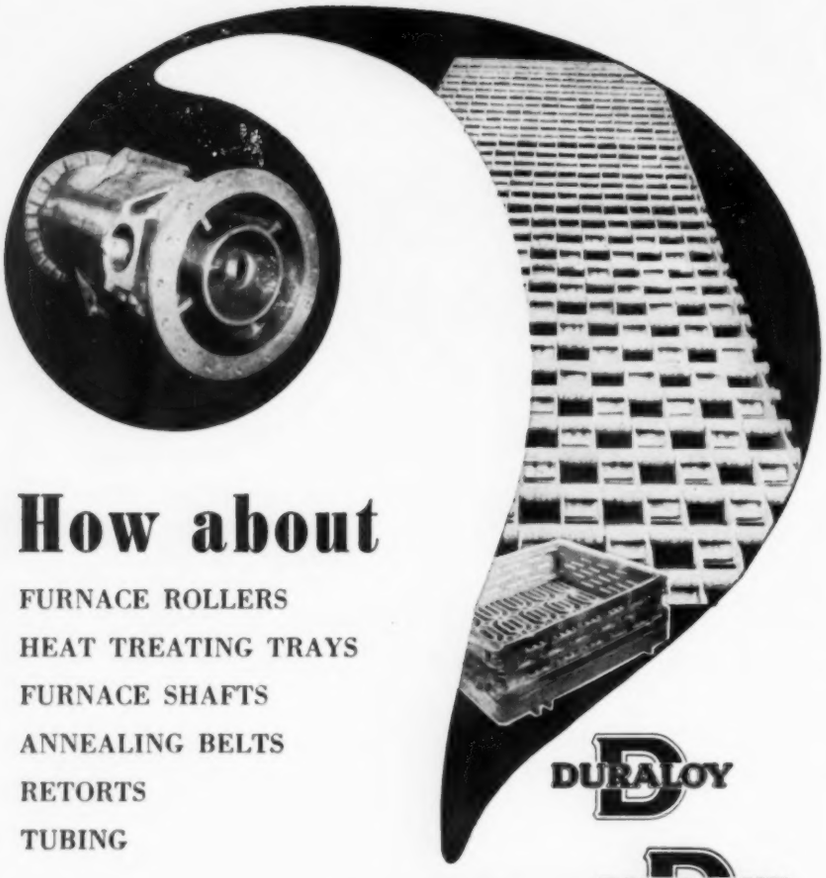
Cinder Notch Stopper

keeps workmen out of a danger zone



Since the Bailey Stopper is controlled remotely, no workman need approach the cinder notch—assuring safe, dependable closing every time. Gravity action inserts the bott in the monkey, and an air or steam powered cylinder withdraws the stopper to the "out" position. Design is such that alignment is true at all times. For durability, both the bott and rod are water-cooled.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA



How about

FURNACE ROLLERS
HEAT TREATING TRAYS
FURNACE SHAFTS
ANNEALING BELTS
RETORTS
TUBING

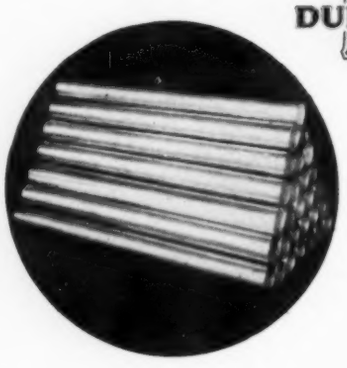
DURALOY

DURASPUN

Which are
Heat Resistant

Corrosion Resistant

Abrasion Resistant



When ready to order, how about checking with us here at DURALOY? For more than thirty years we have specialized in high-alloy castings. In fact, we were among the first to produce static castings and the first to produce centrifugal castings. We are old hands at producing castings alloyed to fit each specific requirement and to finish them to any extent desired.

Melt, castings and finishing are carefully controlled and quality tested by our staff of metallurgists, chemists, X-ray and gamma ray technicians. If you would like more preliminary information, send for Bulletin No. 3150-G

THE DURALOY COMPANY
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

of the shaft is scheduled to start in three years. When in full operation about 1969, the mine is expected to produce 3,000,000 tons or more annually of high grade iron ore.

The dredging project to expose the ore is said to be the biggest operation of the type ever undertaken. The two dredges each house pumps driven by 10,000 hp electric motors, and two other pumps of comparable size on each line means a total of 60,000 hp will be used, moving water and silt an extreme distance of 5 miles and as high as 900 ft.

The water will be removed and returned to the lake 12 times, it is estimated, to provide the vehicle for carrying off the silt.

AMERICAN PULLEY CO. ACQUIRES TRUCK LINE

▲ The American Pulley Co. announces the purchase of the assets of Safeway Industrial Equipment Corp., Chicago, Ill., manufacturer of a complete line of manually and electrically operated hydraulic lift trucks.

American Pulley Co. by this move will widen its markets to include the materials-handling tasks which require more than horizontal handling and yet cannot be done efficiently by the larger full-powered lift trucks due to their size and cost.

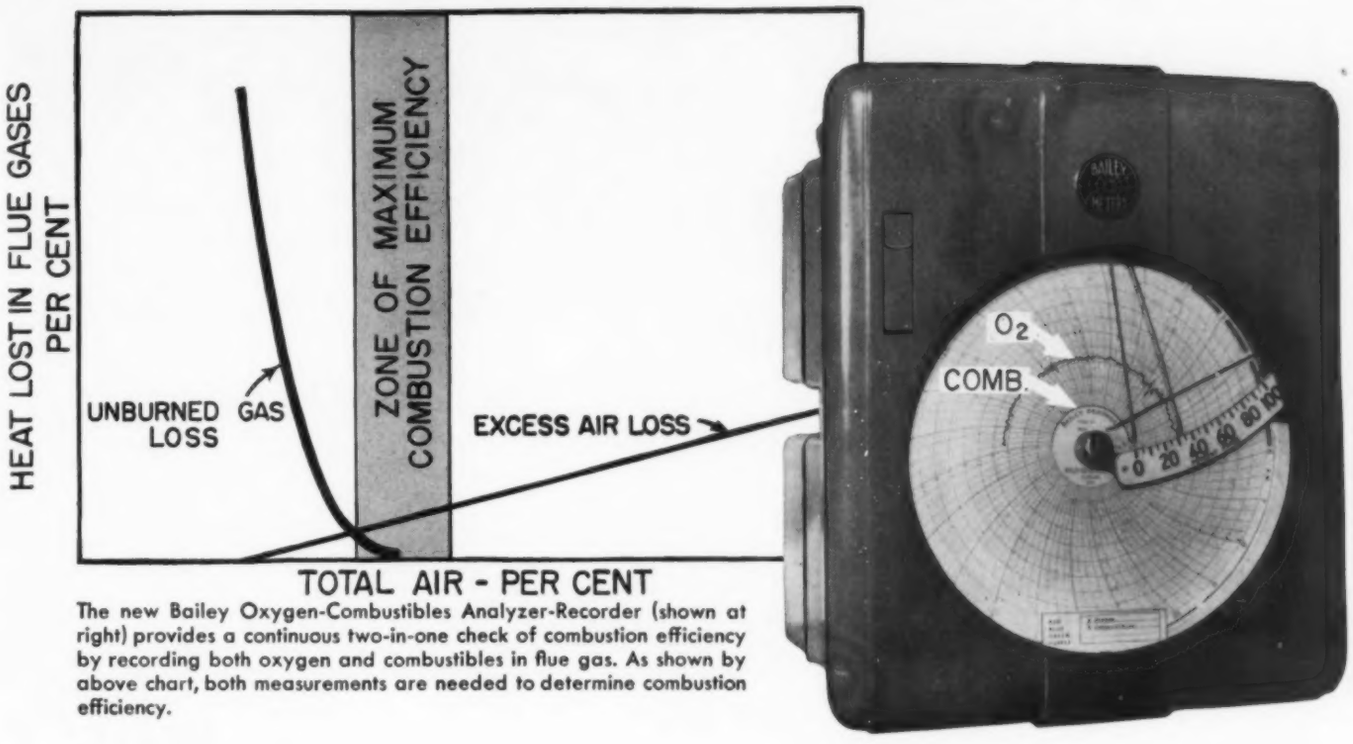
It is planned to merchandise these lift trucks under the trade name of "American Safeway" and through the nation-wide American Pulley distribution network. Mr. Harry T. Carroll, former president of the Safeway Industrial Equipment Corp., has joined the American Pulley Co. and will operate out of the Chicago address, where stocks will continue to be maintained.

In the near future, manufacturing and engineering will be transferred to the American Pulley facilities in Philadelphia.

Future Meetings

▲ The Twenty-third annual meeting of the Electric Metal Makers Guild, Inc. will be held on June 2, 3, 4, 1955 at the Hotel Fort Shelby, Detroit, Mich.

▲ The first Technical Conference and Exhibit on Magnetism will be held at the William Penn Hotel, Pittsburgh, Pa., June 14-16, 1955.



The new Bailey Oxygen-Combustibles Analyzer-Recorder (shown at right) provides a continuous two-in-one check of combustion efficiency by recording both oxygen and combustibles in flue gas. As shown by above chart, both measurements are needed to determine combustion efficiency.

BAILEY announces · · · New 2 in 1 way to measure Combustion Efficiency

The new Bailey Oxygen-Combustibles Analyzer-Recorder gives you a continuing double check on combustion economy. It's fast response measures and records:

1. Excess air—regardless of the fuel or combinations of fuels being burned.

2. The mixing efficiency of your fuel-burning equipment—by indicating the amount of combustibles in your flue gas, resulting from incomplete mixing of fuel and air.

Combustion efficiency depends upon fuel-air ratio. Too much fuel can be even more costly than too much air. And because of the interdependence of these two factors, no control that measures only one of them can give you complete protection.

Now, for the first time, you can check *both* with a *single* fast acting instrument, using the new Bailey Oxygen-Combustibles Analyzer-Recorder for industrial furnaces, kilns, heaters and boilers.

Fuel economy improves as excess air is reduced —until unburned fuel begins to show up in the flue gas. When this happens, combustion efficiency drops off sharply if there are further decreases in the air-fuel ratio. That's why combustion gases must be analyzed for *both* oxygen and combustibles to get a true indication of efficiency—and that is why Bailey coordinates both measurements on the same chart, to show when excess air may be reduced safely without danger of greater losses from unburned gases.

The Bailey Oxygen-Combustibles Analyzer is an approved combustion safeguard.

Ask your local Bailey engineer for suggestions on application. Equipment details in Product Specifications E65-1 and E12-5. P31-1

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

For Power And Process

Wagner®
ELECTRIC MOTORS
...the choice of leaders in industry

NEW!
Wagner Type DP* Motors

Doubly Protected

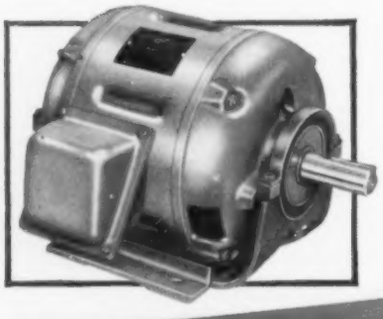
* Wagner Type DP Motors are protected by rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity.

* Enclosures are drip-proof plus! Air intakes are located at the bottom of the endplates — air outlets are located at the base of the frame, one on each side. Specially designed baffles provide protection for the stator windings.

The Wagner line of polyphase, drip-proof general purpose motors—rerated to the new NEMA Standards—pack more power into smaller frames, but give you the same high Wagner Quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many, many years. These new Wagner Motors are fully protected in the ball bearing models. Their construction makes them completely drip-proof — and virtually splash-proof. The extra large, diagonally split conduit box makes wiring easy. Smaller size and lighter weight means more economical handling and installation.

These new rerated Wagner Motors retain the features desired by plant engineers and maintenance men. They will operate for years without regreasing. But . . . when lubrication *is* necessary or desirable, you *can* lubricate these motors because they are provided with two lubrication openings.

Bulletin MU-202 gives full information—write for your copy today.



AVAILABLE WITH RESILIENT MOUNTING —SLEEVE BEARINGS UP THROUGH 5 HP.

These Wagner standard motors, in ratings up through 5 horsepower, can be used for specialized applications because they are available in sleeve bearing models with endplates that will take resilient mounts.

You can look to Wagner for a complete line of standard motors for specialized applications. The wide range of types and sizes permit the selection of a standard motor for almost any need.

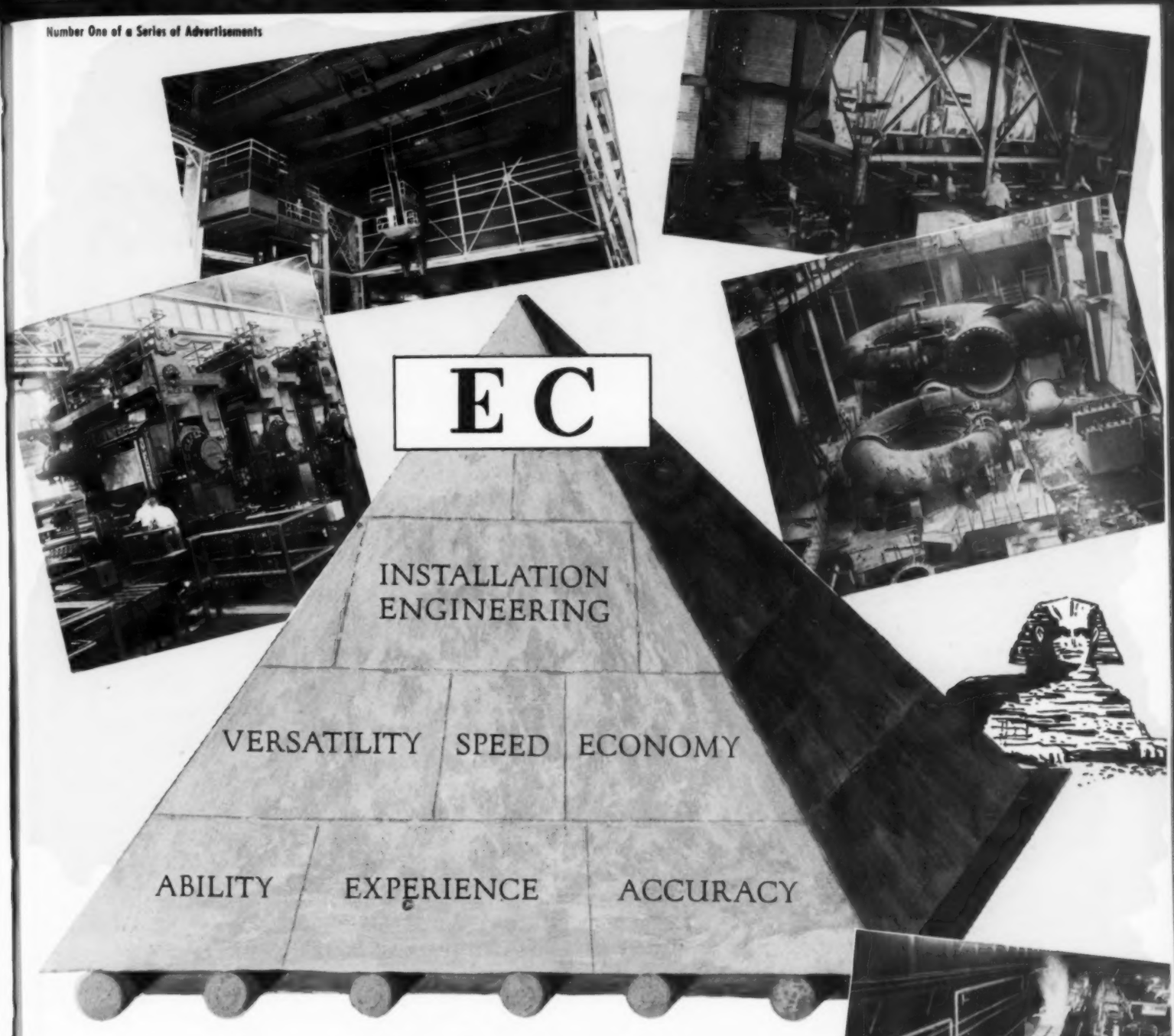
Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M55-6

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

Number One of a Series of Advertisements

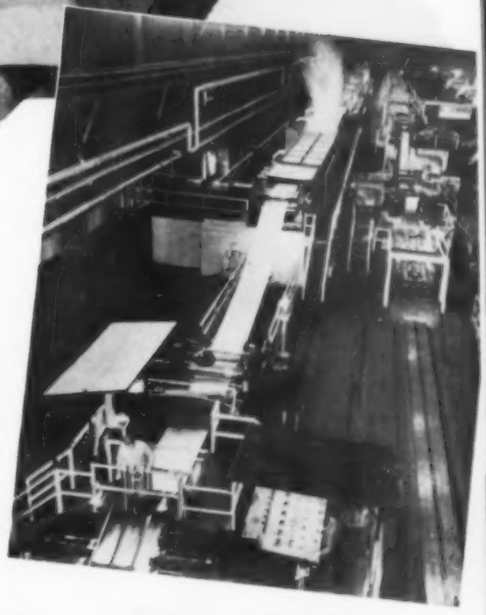


The massive Pyramids at Giza were painstakingly built as a lasting memorial. Their existence remains a tribute to precision craftsmanship and installation engineering. Although methods have been changed to coincide with the machine age the same attention to engineering detail has enabled the Eichleay Corporation to create impressive installations in all fields of industry.

The installation of mechanical equipment requires careful planning and specialized engineering, in all of which the Eichleay Corporation has shown leadership. Eichleay versatility and outstanding ability have been demonstrated by the speedy and economical solution of difficult installation projects in ferrous and non-ferrous plants, paper mills, power companies and many other industries throughout the nation.

To study your particular project and plan a construction schedule for you, which places your new facility in early operation or minimizes interruptions when existing facilities are involved, is one of the many Eichleay services offered to industry.

Write for Illustrated Booklet



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ESTABLISHED 1875

CORPORATION
33 South 19th St., Pittsburgh 3, Pa.
681 Market St., San Francisco 5, Calif.

Eichleay Services

- Industrial Installations
- Construction of Heavy Foundations
- Building and Machinery Moving
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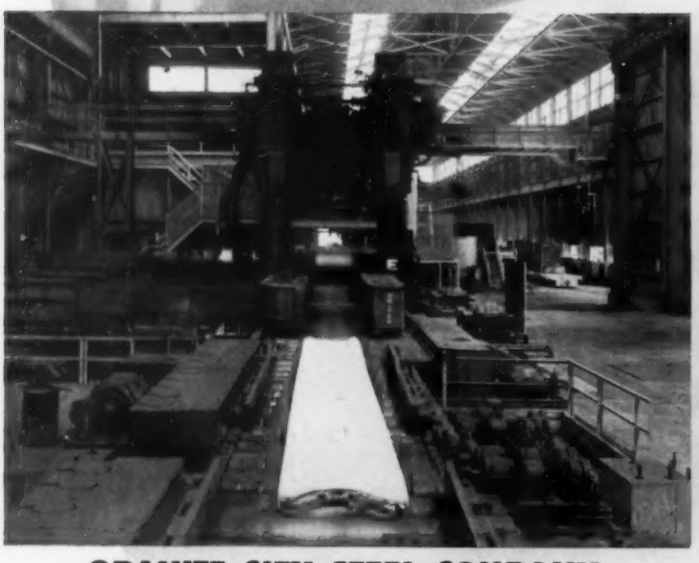
"bearing maintenance

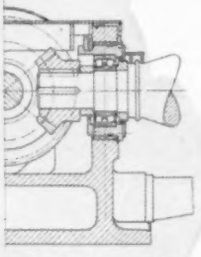


GRANITE CITY STEEL COMPANY

LONE STAR STEEL COMPANY

APPLICATION

Drawing shows how designers apply SKF Spherical Roller Bearings to both approach and delivery tables of blooming mills like the United Engineering & Foundry installation at Granite City (on the left).



SIGNIFICANCE

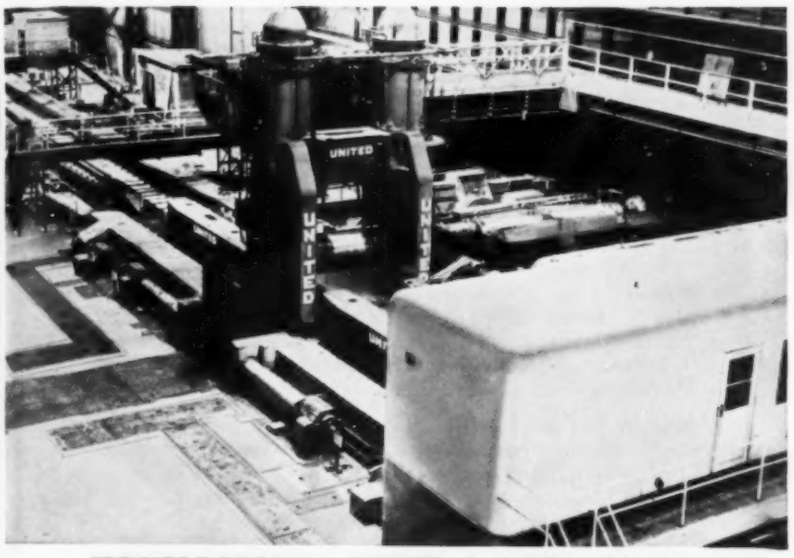
Table roll bearings under the manipulators particularly must be able to take it—*heavy, intermittent radial load—thrust load—shock load!* SKF Spherical Roller Bearings stand up in this application and there is *no* "pounding-out" of housing bores.

The three reasons that could make SKF Spherical Roller Bearings the answer to your anti-friction problems are:

1. Size for size, SKF Sphericals provide highest capacity.
2. Like all SKF bearings, they are made to the industry's highest quality standards.
3. SKF Field and Home Office Engineers, with many types and sizes of *ball* and *roller* bearings to choose from, can provide unbiased and sound advice on how and where to install what bearing.

negligible"

on UNITED® Blooming and Slabbing Mill Tables—SKF Equipped



YOUNGSTOWN SHEET & TUBE COMPANY

That's the report from United Engineering and Foundry Company who first tried out SKF Spherical Roller Bearings on mill equipment more than 25 years ago . . . since then on blooming and slabbing mill tables.

Then it was an innovation; now it's a *trend!*

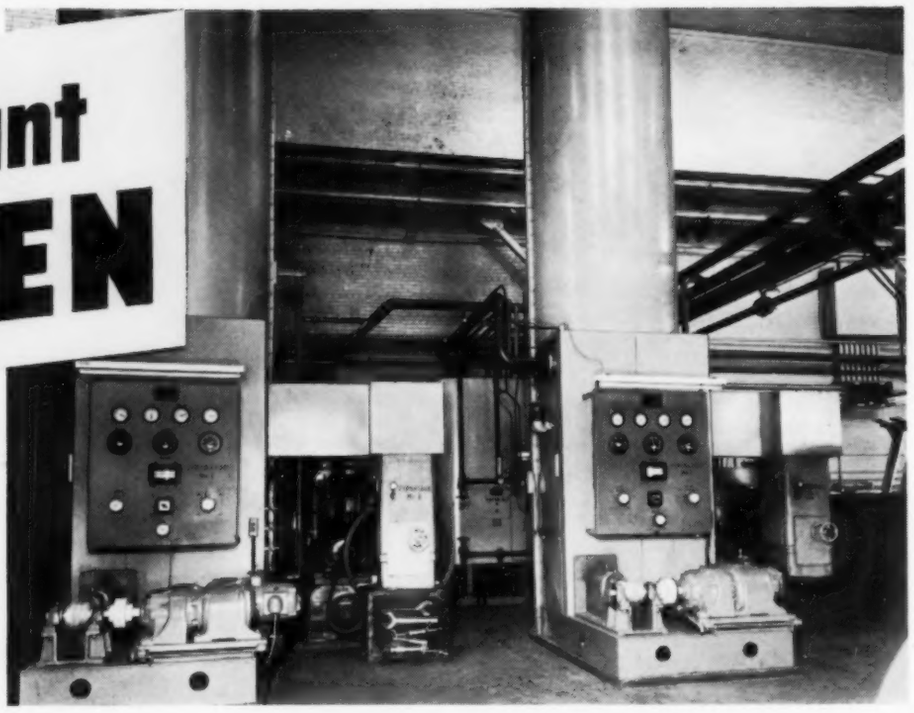
Pictured here are United Engineering and Foundry installations in three mills – all in service over two years.

Throughout the steel industry, SKF Spherical Roller Bearings are not only going into *new* mills, but are also replacing other types of bearings that have been tried and found wanting in existing mills. 7615

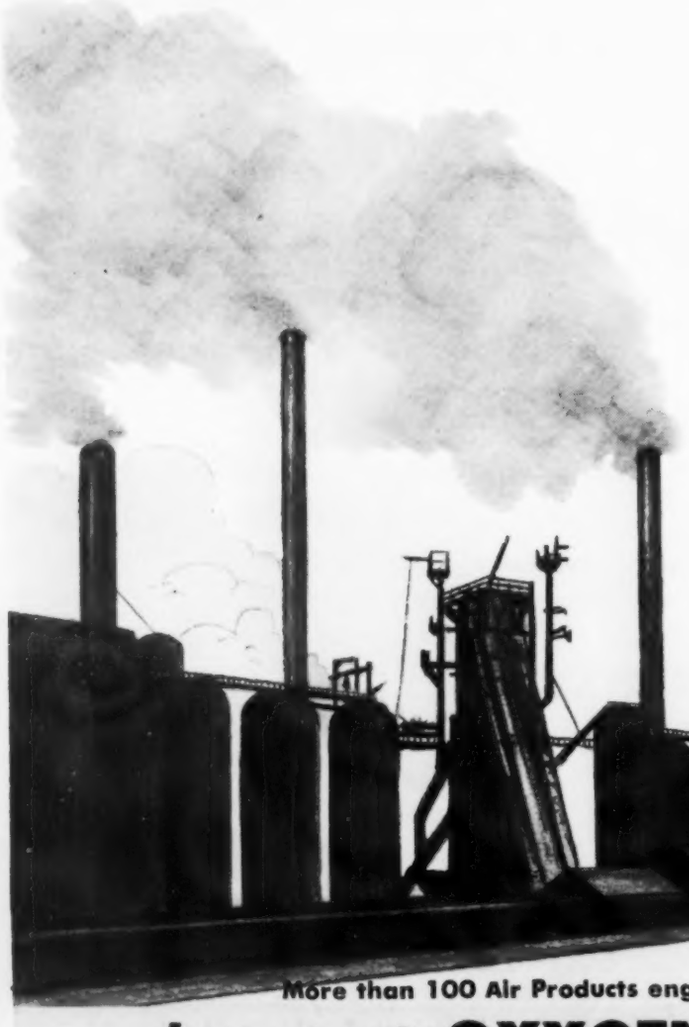
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.,
manufacturers of SKF *and* HESS-BRIGHT® *bearings.*

SKF®
BALL AND ROLLER BEARINGS

Abundant OXYGEN



—At Rock-Bottom Cost with *Air Products* "On-Location" Generators



Plentiful, low-cost oxygen has become tremendously important in modern steel-making. With free raw material in infinite abundance in the air around us, it is only common sense to have equipment that will convert this unlimited asset into valuable oxygen. It is done without capital investment by installing an Air Products Multiple Generator on a lease basis.

When you make your own oxygen on your premises, you have no transportation costs . . . no worries regarding delivery failures or shortages . . . your oxygen requirements are piped directly from your own generator to all the points in your plant where it is needed.

Air Products, Incorporated, provides equipment for all requirements with:

Large Capacity Tonnage Generators **for unlimited quantities of oxygen and nitrogen, in standard or special models, high or low pressure cycles**

and

"Packaged" High Purity Generators **producing high-purity oxygen and nitrogen simultaneously or individually.**

Generators are furnished to produce any quantity at any purity and pressure.

Let us have your requirements. We will be glad to give you actual figures showing savings you can make.

Air Products INCORPORATED

Dept. P, Box 538, Allentown, Pa.

More than 100 Air Products engineers are at your service.

Low-cost **OXYGEN . . . NITROGEN**

Personnel News...

Roger M. Blough was named to succeed **Benjamin F. Fairless** as chairman of the board and chief executive officer of United States Steel Corp. Mr. Fairless, who reached the normal retirement age of 65, will continue as a member of the board of directors and the finance committee of the corporation, and was also appointed chairman of the executive advisory committee, a newly formed committee of the board of directors. Mr. Fairless was elected president of U. S. Steel in 1938. He has spent more than forty years in the steel industry, twenty of which have been in high executive positions with the corporation. The son of a coal miner, Mr. Fairless was born in Pigeon Run, Ohio, and once taught country school to earn money for a college education. In 1928, Mr. Fairless was president and general manager of Central Alloy Steel in Massillon, Ohio. Two years later, he became executive vice president of Republic Steel Corp. When Carnegie-Illinois Steel Corp. was formed in 1935, Mr. Fairless became its president. In 1952, he succeeded **Irving S. Olds** as chairman of the board of U. S. Steel, and also was made chief executive officer of the corporation. Mr. Blough was born near Johnstown, Pa. He also taught school in the early days of his career. Mr. Blough was appointed general solicitor in charge of all legal matters for United States Steel Corp. of Delaware in 1942. In 1951, he became executive vice president — law and secretary, and a director of United States Steel Co., formed at that time as a result of the merger of four U. S. Steel subsidiaries. He served in these executive positions until his election as vice chairman of the board in 1952.

Kermit L. Johannsen has been named assistant to vice president — operations — steel, of United States Steel Corp., with responsibility for maintenance planning. He started with U. S. Steel as an electrician at the Gary Sheet & Tin Plant in 1936 and moved to Dravosburg, Pa., in 1937 as electrical construction inspector for the new Irvin Works. After completion of the plant he received several promotions before transferring to Duquesne Works as assistant superintendent of maintenance. In 1951 he was made division superintendent of maintenance and utilities at Fairless Works in Morrisville, his position at the time of his present appointment.

George Lee Berry, formerly manager of the plant and production engineering department, Steel Division of the Ford Motor Co., has been named chief engineer of Jones & Laughlin Steel Corp. Mr. Berry joined the Carnegie-Illinois Steel Corp. in 1937 as an inspector of construction at its new Irvin Works. Through a succession of positions at Carnegie-Illinois, he rose to assistant chief engineer at Irvin Works, where he supervised, among other jobs, the installation of a multi-million-dollar sheet and tin mill expansion program. He joined Ford Motor Co. in 1949 as manager of the Steel Division's plant and production engineering department. At Ford he initiated, planned, and directed a multi-million-dollar modernization and expansion program.

William A. Steele was elected vice president in charge of operations of Wheeling Steel Corp. He succeeds **J. H. McElhinney,** who died on April 12. Mr. Steele has been associated with Wheeling since 1943 when he was made general manager of the Benwood Works. Prior to that, he had been affiliated with Crucible Steel at Midland, Pa. for twelve years. In 1950, he was put in charge of Wheeling's Steubenville Works.

Samuel C. McDowell, formerly assistant chief industrial engineer for Republic Steel Corp., has been named manager of the Pressed Steel Division. He was employed by Westinghouse Electric Corp. prior to becoming assistant district industrial engineer at Republic's Youngstown steel plant in 1939. In 1940 he was named division industrial engineer at the company's Berger Manufacturing Division in Canton, Ohio, and in 1948 became plant superintendent. He was made assistant chief industrial engineer in 1950.

A. H. Shonkwiler has been appointed general manager, Steubenville Works, Wheeling Steel Corp. Mr. Shonkwiler is a veteran in the steel industry, having previously been with Bethlehem Steel Corp., and Otis Steel. He has been assistant general manager of Steubenville Works since 1950. **W. H. Holman** was named assistant general manager at Steubenville Works. He was with Carnegie-Illinois Steel and Jones & Laughlin before joining Wheeling in 1949 as assistant blast fur-

ROGER M. BLOUGH

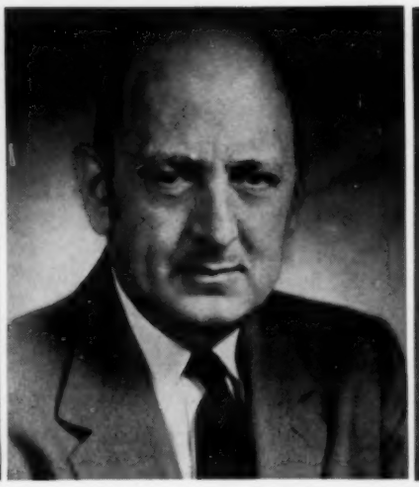
BENJAMIN F. FAIRLESS

KERMIT L. JOHANNSEN

GEORGE LEE BERRY

FRANK V. TERRELL

SIMON FEIGENBAUM



L. S. WILCOXSON

M. NIELSEN

nace superintendent at the Benwood Works. In 1950, he was transferred to the Steubenville blast furnace operations and, since last year, has been superintendent of the five blast furnaces and sintering plant there.

Frank V. Terrell was named general superintendent of the Christy Park Works of U. S. Steel Corp.'s National Tube Division at McKeesport, Pa. Mr. Terrell succeeds **John W. Hacker,** who has been acting in the capacity of general superintendent of the plant. Mr. Hacker is retiring after 15 years in executive capacities with National Tube.

Simon Feigenbaum has been named chief industrial engineer of Jones & Laughlin Steel Corp. He was formerly chief metallurgist at J&L's Pittsburgh Works Division. Succeeding Mr. Feigenbaum at Pittsburgh Works is **George G. Blean,** who moves up from assistant chief metallurgist. **W. H. Richey,** metallurgist—strip mill, is promoted to assistant chief metallurgist at Pittsburgh Works, succeeding Mr. Blean.

L. S. Wilcoxson who has been vice president in charge of research of the Babcock & Wilcox Co. since 1945 has been appointed vice president in charge of the Boiler Division of the company. In his new position Mr. Wilcoxson will relinquish his research responsibilities to take charge of all activities in the Boiler Division which has six manufacturing plants throughout the nation.

M. Nielsen, vice president of the Babcock & Wilcox Co. was elected by the board of directors to the newly created post of executive vice president of the company. He was also reelected to the board.

Wallace B. Leyda was appointed chief metallurgist for the Ohio Seamless Tube Division of Copperweld Steel Co. Mr. Leyda comes to Ohio Seamless from Northern Indiana Brass Co., where he held a similar position. He worked for fifteen years with National Tube Division of U. S. Steel Corp. and three years with A. O. Smith Co.

H. Maurice Banta has been named technical adviser at Battelle Institute. In his new position, he will advise the Institute's clients in the iron and steel and metal fabricating industries on the formation of their research programs. Mr. Banta has directed metallurgical research at Battelle since 1942. Prior to that time he held research and production positions with the Central Alloy Steel Co. and the Jones and Laughlin Steel Corp.

Carl D. Burkland has been promoted to the position of chief industrial engineer by Wheeling Steel Corp. Mr. Burkland joined Wheeling in 1946 as a production engineer at the Yorkville, Ohio Works.

Paul R. Grossman who has been chief research engineer for the Babcock & Wilcox Co. at its research center in Alliance, Ohio has been appointed director of research.

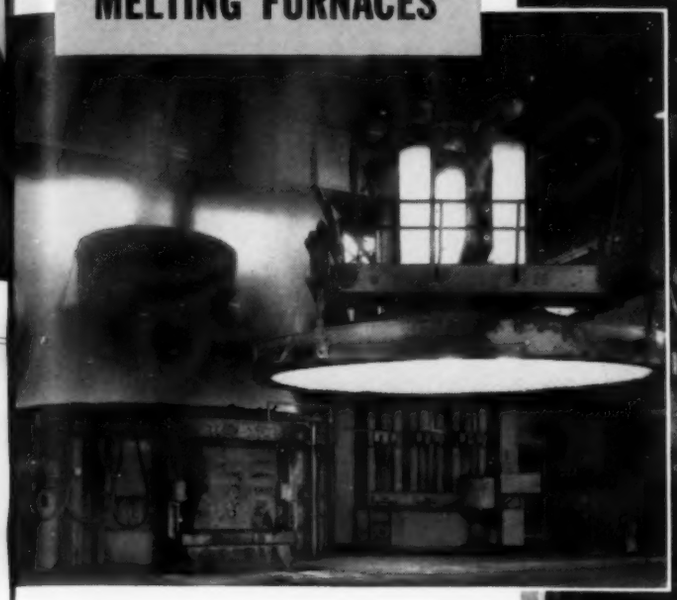
PAUL R. GROSSMAN

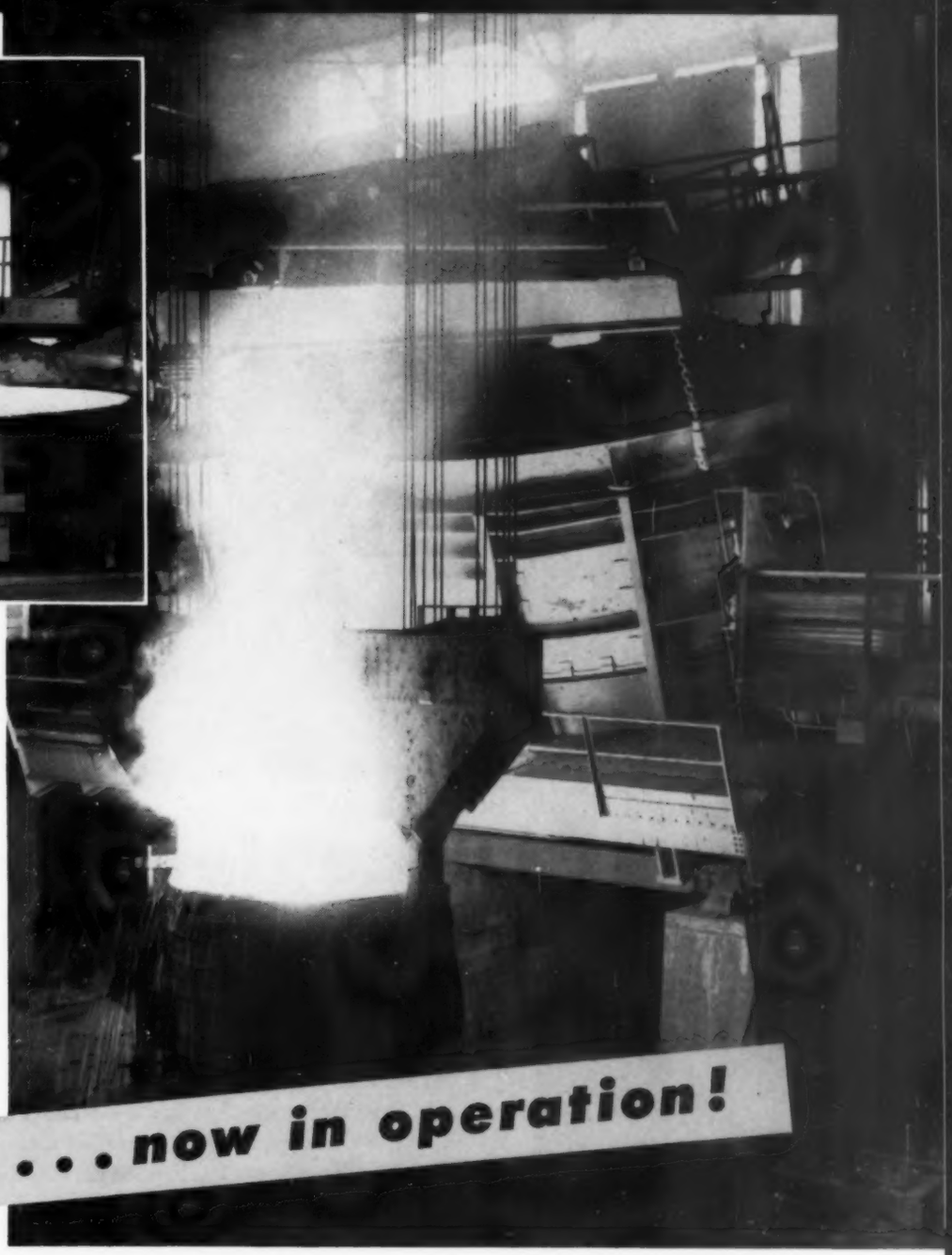
William G. Findlay is the new manager of the Detroit, Mich., plant of Joseph T. Ryerson & Son, Inc. He succeeds **Emroy M. Vehmeyer** who has retired after 46 years with the company.

S. W. Stouffer has been appointed assistant director of construction and maintenance of Jones & Laughlin Steel Corp. He was formerly manager of construction in the general office of the corporation. Mr. Stouffer joined J&L in 1931 as a student engineer at Aliquippa

Heroult
ELECTRIC MELTING FURNACES

TOPS FOR PRODUCTION OF HIGH GRADE STAINLESS, ALLOY AND RIMMING STEELS





World's Largest Electric Furnaces

. . . now in operation!

INSTALLED in the ultra-modern mill of McLouth Steel Corporation, in Detroit, these giant *200-Ton* Heroults are the largest electric melting furnaces ever built. With an inside shell diameter of 24'6", they have a rated charge capacity of 400,000 pounds, and each is designed for efficient operation on 25,000 to 33,000 KVA transformer capacity. Featuring a swing-type roof, these furnaces are equipped with the finest, most up-to-date mechanism and electrical controls available.

McLouth's adoption of electric furnaces of this size sets a precedent. It is a "first" which should conclusively prove that, in addition to closer control, higher uniformity, better performance, and greater safety, large capacity Heroult Electric Furnaces are an economically sound investment—even for high tonnage steel-making.

We welcome an opportunity to help you select and install the furnace best suited to your particular requirements.

ASK FOR NEW CATALOGUE. *Contains latest information on modern electric furnaces—types, sizes, capacities, rating, etc. Write Pittsburgh Office for free copy.*

AMERICAN BRIDGE DIVISION, UNITED STATES STEEL CORPORATION
GENERAL OFFICES: 525 WILLIAM PENN PLACE, PITTSBURGH, PA.

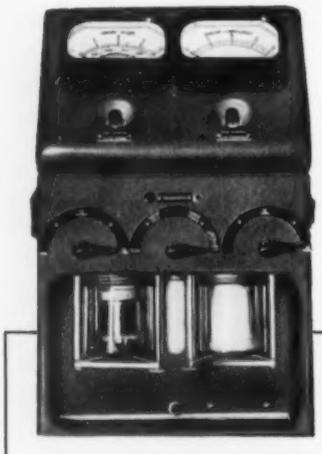
Contracting Offices in New York, Philadelphia, Chicago, San Francisco and other principal cities.
United States Steel Export Company, New York

USS

UNITED STATES STEEL

Crucible Steel, Midland, Pennsylvania

"Cities Service Heat Prover helps make special steel, saves fuel"



THE CITIES SERVICE HEAT PROVER . . .

Not an instrument that you buy . . . but a service we supply! . . . FREE!

Crucible Steel Company of America is another leading steel company that has found the Cities Service Heat Prover a valuable aid in its furnace operation.

Here's what Crucible has to say about the Heat Prover at its Midland Works, one of several where it is in constant use.

"The Heat Prover has become our standard tool for the setting up and checking of combustion controls on our many furnaces at Midland. It has also helped immensely in setting up special atmospheres for special grades of steel by providing fast and reliable analyses, and has been particularly instrumental in the improvement of fuel economy. Cities Service has kept the Heat Provers in perfect running order and on many occasions has gone out of its way to help us."

You, like Crucible Steel, can achieve better results in *your* furnace operation with the Cities Service Heat Prover. Supplied and maintained free by Cities Service, it offers easy portability, rapid continuous sampling, simultaneous reading of oxygen and combustibles. For more information, talk with a Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N.Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Works. He became millwright foreman in 1934 and production foreman in the tin plate department in 1937. He was named superintendent of the Eliza Furnaces utility and mechanical department in 1947; resident construction engineer at Aliquippa in 1949, and manager of construction in September of 1950.

Harry T. Burke has been appointed chief engineer of the E. W. Bliss Co.'s Hastings Division at Hastings, Mich. He had formerly been assistant to the chief engineer since 1949.

Irving A. Painchaud, formerly with Salem-Brosius, Inc., has been appointed design engineer for the Electric Furnace Co.

C. C. Fuller was named a vice president of the Foxboro Co., augmenting the sales management staff. **H. O. Ehrisman** was appointed general sales manager, and **J. J. Burnett** was named field sales manager.

George E. Brandon, general manager of Semet-Solvay division of Allied Chemical & Dye Corp., retired April 30. Mr. Brandon who was previously superintendent of Semet's Ashland, Ky., and Ironton, Ohio, coke oven plants was appointed general manager in 1935. He had been with Semet-Solvay for 38 years.

Chandler G. Lewis was appointed general manager of the Martins Ferry Plant of Wheeling Steel Corp. Mr. Lewis was formerly chief industrial engineer.

J. O. Phillips has been named assistant to the executive vice president of sales for Heppenstall Co. He will serve as sales administrator and coordinator. **George H. Wurster** has been appointed manager of forging and die steel sales.

A. E. Hohman, advertising manager of Blaw-Knox Co. since 1944 has been appointed coordinator of special sales activities. In his new position, Mr. Hohman will serve the sales department in the evaluation of advertising, sales promotion and special marketing activities. **Paul F. Vollmer** has been appointed advertising manager, to succeed Mr. Hohman. Mr. Vollmer has served as assistant advertising manager since 1949, having joined Blaw-Knox in 1942.

A. L. Davis has been named president and treasurer of the Pennsylvania Engineering Corp. **William S. Wheeler,** long time president becomes chairman of the board. **Clark Rossiter** was named executive vice president and general manager, and **P. M. Pattison,** vice president and secretary.

C. I. (Shay) Young has been named vice president and general manager of Laclede-Christy Division of H. K. Porter Co., Inc. Mr. Young previously was vice president in charge of operations at all Laclede-Christy plants. Before coming to Laclede-Christy, he had more than 30 years experience in the refractories industry. He was assistant to the vice president of operations of Harbison-Walker Refractories Co. and more recently was executive vice president in charge of operations of Union Fire Brick Co.

John S. Hutchins, president of Ramapo Ajax Division, American Brake Shoe Co., has been named to additional duties as president of the National Bearing Division. Mr. Hutchins joined the sales department of American Brake Shoe in 1925 and has been a vice president of the company since 1946. **Thomas W. Pettus,** also a vice president of American Brake Shoe Co. and formerly president of the National Bearing Division, is assigned to over-all railroad sales for the company. Mr. Pettus joined the company in 1928 and has been a vice president since 1946. Named executive vice president of National Bearing Division is **Charles M. Ruprecht,** president of Electro-Alloys Division since 1953. **Paul L. McCulloch, Jr.,** sales manager of the Electro-Alloys Division since 1953, succeeds Mr. Ruprecht as division president.

Robert M. Snyder and **Wilfred G. Shedd** were named sales engineers in the Chicago industrial sales office of Surface Combustion Corp.

Donald L. Archibald was appointed district sales manager in the New England area for Joy Manufacturing Co.

J. Robert Kelley, formerly vice president and general manager of the Shaw-Box Crane & Hoist Division, Manning, Maxwell & Moore, Inc., has been appointed executive vice president. **Chester H. Butter-**

HARRY T. BURKE

IRVING A. PAINCHAUD

C. C. FULLER

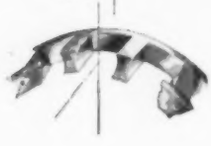
H. O. EHRISMAN

Truer Rolling AND Longer Life...

Through RIGHT-ANGLE DESIGN.....

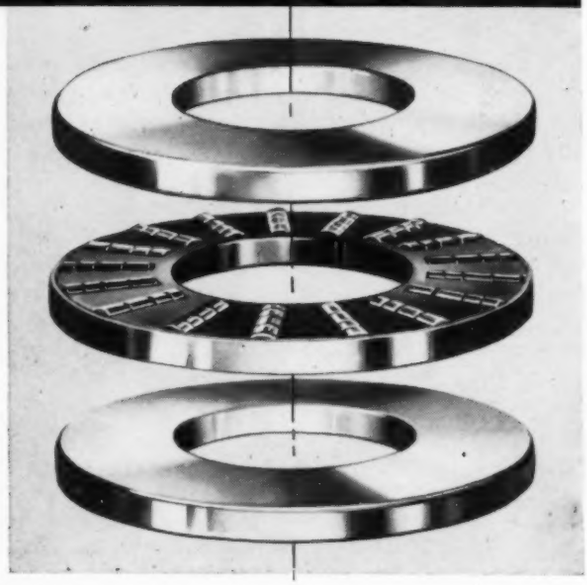
RIGHT-ANGLE
Roller Ends, precisely square to avoid end-rub, oscillation and side-shock.

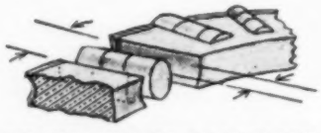
RIGHT-ANGLE
Bearing Surfaces with parallelism that results in unwavering right-line rolling.



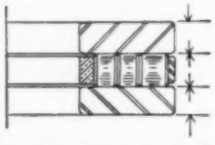
RIGHT-ANGLE
Separator Slots accurately machined to prevent roller skew, slide and uneven wear.

Through PRECISION-PARALLELISM





PRECISION-PARALLELISM
between rollers and matched thrust plates to preserve maximum capacity and eliminate Brinell effect.



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between rollers and machined separator slots to assure perfect alignments; minimize sliding friction and wear.

ROLLWAY Radial and Thrust Cylindrical Roller Bearings

The advantages of Rollway's *right-angle design* and *precision parallelism* are readily apparent: Rubbing or sliding friction is negligible. Roller end-wear is practically nil. Starting torque is lower. Bearing life is extended. Shut-downs for bearing maintenance and replacement are fewer and farther apart.

Rollway's complete engineering and metallurgical services will gladly work with you on your problems. Simply write or wire any office. No cost. No obligation.

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COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Rollway Bearing replacements are available through authorized distributors in principal cities. Consult your classified phone directory.

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ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

field was named vice president of operations, and **Charles A. Moore** was appointed vice president and treasurer.

James A. Arter has been appointed vice president in charge of manufacturing for Ampco Metal, Inc. **J. P. Henry,** formerly assistant general sales manager, has been appointed general sales manager. **R. J. Severson,** formerly manager of technical sales will assume the duties of assistant general sales manager.

Edwin R. Broden was elected executive vice president, of SKF Industries, Inc. He was formerly executive vice president, and a director, of the Carborundum Co.,

EDWIN R. BRODEN

which he joined in 1944, as vice president in charge of operations. Previously, he was a division manager, of the Blaw-Knox Co.

J. A. Succop, chief metallurgist of Heppenstall Co., has been presented the David Ford McFarland Award by the Penn State Chapter of the American Society of Metals. The award is presented annually to a metallurgical graduate of Penn State in recognition of achievement in metallurgy. It is named in honor of the late **Professor McFarland,** co-discoverer of helium, who was head of the Department of Metallurgy from 1920 to 1945.

E. M. Detwiler has been appointed works manager of Lake Erie Engineering Corp. Mr. Detwiler, general superintendent since 1953, was formerly assistant works manager of Worthington Corp.'s Buffalo, N. Y., plant. Three other newly created offices have been filled by **William H. Bennett** as sales manager, **Robert J. Fuller** as assistant treasurer and **Robert W. Gerhardt** as sales project engineer.

F. L. Humphrey, Jr. was named district manager for the Elliott Co.'s Atlanta territory.

Robert W. Marvin was named general manager of the Engineering Works Division, Dravo Corp. Mr. Marvin joined Dravo in 1927 and was named assistant general manager of the division in 1954.

S. M. Stoler has been elected president of R-S Furnace Co., Inc. **H. E. Curll,** was elected vice president and **R. M. Boyd,** secretary.

Drew M. Thorpe has been appointed executive vice president of General Refractories Co. He formerly served as a vice president of the firm.

Robert S. Stevenson, executive vice president of Allis-Chalmers Manufacturing Co. since July, 1952, has been elected president. He succeeds the late **William A. Roberts,** who died April 12.

Roy E. Carter has joined the Green River Steel Corp. as master mechanic. **John Christie,** formerly with National Forge and Ordnance Co., was appointed general foreman, press shop.

Francis B. Makens has been appointed general superintendent of the Chicago, Ill., plant of Joseph T. Ryerson & Son, Inc.

H. L. Stockdale has been appointed to the presidency of the Insul-Mastic Corp. of America, succeeding **Clifford Off.**

H. L. STOCKDALE

C. Davis Blackwelder, a vice president of Reynolds Metals Co., has been appointed consulting engineer for the Operations Division of the company. Mr. Blackwelder was formerly chief engineer of the company.

W. J. Brigham, formerly district manager of the Timken Roller Bearing Co.'s Cincinnati office, was named district manager of the company's Detroit office. **John J. McGrann,** the Houston district manager, assumes Mr. Brigham's post at Cincinnati. Succeeding Mr. McGrann as Houston district manager is **Ralph Preston.**

Alfred R. Florio was appointed general manager of the Sheet Metal Specialty Division of Follansbee Steel Corp. Mr. Florio, who is also vice president of the Louis Berkman Co., Steubenville, Ohio, will be responsible for the Division's complete facilities for contract stamping and the production of blue and galvanized furnace pipe and elbows.

H. Wynn Gethin has been transferred from St. Louis, Mo., to Pittsburgh, Pa., as district sales manager of Laclede-Christy Co., Div. of H. K. Porter Co., Inc. **Burton N. Wright** succeeds Mr. Gethin as manager of the St. Louis district.

Charles Bultman, Detroit district sales manager of Pangborn Corp., has transferred to the field sales department where he will assume responsibility for promotion of sales of new blast equipment, primarily sheet and plate blast machines. **David Bair** has succeeded Mr. Bultman as manager of the Detroit district.

D. P. Cromwell, formerly manager of Coke Ovens and Blast Furnaces for the Ford Motor Co., has become associated with the William M. Bailey Co. as sales manager, Ohio District.

Richard A. Geuder has been appointed assistant general sales manager of the Reliance Electric and Engineering Co., and **Edward E. Helm,** the company's sales vice president, has been assigned the added duties of coordinator of all activities in merging the efforts of

RICHARD A. GEUDER

the recently acquired Reeves Pulley Co. Division with the other divisions of Reliance in Cleveland and Ashtabula, Ohio.

John J. Green has been named service engineer in the Pittsburgh, Pa., office of the Vanadium Corp. of America. Mr. Green comes to Vanadium from Universal-Cyclops Steel Corp., with which he has been associated for the last ten years.

John M. Wilson has been named chief engineer of the development and design division of the engineering department of Minneapolis-Honeywell's Brown Instruments Division.

Dr. Augustus B. Kinzel has been elected vice president — research of Union Carbide and Carbon Corp., succeeding **Dr. George O. Curme, Jr.** Dr. Curme, who is retiring as vice president of the corporation, will continue as a director.

Harold M. Schudt was elected president, Canadian Allis-Chalmers Limited. He replaces **Mark C. Lowe** who resigned after being president of Canadian Allis-Chalmers Limited since 1951 and affiliated with the company since 1947.

R. L. Hibbard has been appointed district manager of the Buffalo district sales territory for Cutler-Hammer, Inc. He had previously been branch manager in Saginaw, Mich. **K. L. Smith** of the Detroit office has been selected to replace Mr. Hibbard in Saginaw.

Alfred E. Tarr, formerly manager of the sales engineering division of Leeds & Northrup Co., has been named assistant to the president.

ALFRED E. TARR

C. J. Rowles has been named executive vice president and a director of the Euclid Electric and Manufacturing Co.

C. J. ROWLES

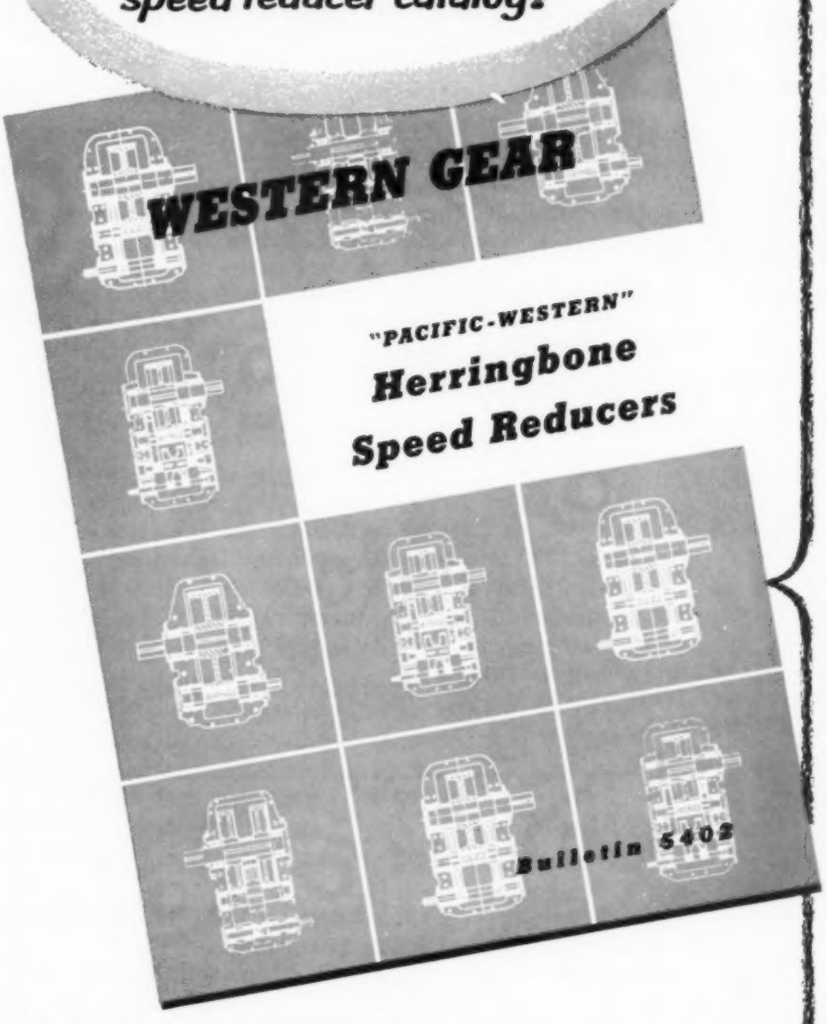
Harry C. Platt has been appointed president of the Engineered Castings Division of American Brake Shoe Co. He succeeds **N. G. Belury,** who was recently appointed sales vice president for the company.

Obituaries

John H. McElhinney, vice president in charge of operations at the Wheeling Steel Corp., died April 12. Mr. McElhinney came to Wheeling in 1936 from Lukens Steel Co.

K. C. Gardner, 78, chairman of the board of United Engineering and Foundry Co. and its chief executive officer died April 15. He first became associated with the company through one of its predecessors, the Lloyd Booth Co. in Youngstown, Ohio, in 1899. Upon the formation of United in 1901, Mr. Gardner was appointed

Have you written for your copy of this important new speed reducer catalog?



LET US PROVE TO YOU that dollar for dollar Western Gear speed reducers offer unequalled efficiency, reliability and longevity. Take advantage of Western Gear's industrial engineering service when replacing old units or designing new installations. Complete engineering service is yours without obligation.

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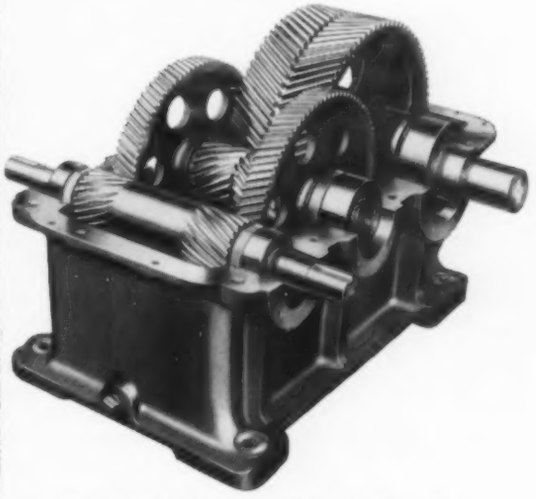

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cool your hot spots

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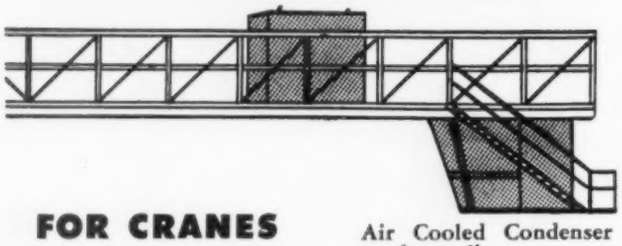

FOR CRANES

You can provide normal working conditions (comfortable temperatures) so that your men will maintain maximum production by efficient use of present facilities. Let us survey your requirements and submit recommendations and cost figures, and describe our conservative through-the-year program.

Bulletin AC-549 describes our complete line or crane cab conditioners for existing as well as new cranes. It's yours for the asking.

Air Cooled Condenser on footwalk.

Cooling Unit in cab—either floor type (shown) or ceiling type. The ceiling type is also used in pulpits as illustrated.

FOR PULPITS

Cool, clean air throughout the pulpit. No drafts . . . no unsightly, expensive ducts. Ceiling type Cooling Unit is above operator's head.

Your choice of heavy duty air cooled condensers for water conservation and lowest operating cost or water cooled condensers for lowest first cost. Ask for Bulletin P-552.

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THE LINTERN CORPORATION

ROUTE 20, EAST • PAINESVILLE, OHIO

machinery sales engineer. He was elected to the board of directors in 1911, vice president in 1928, advanced to general manager of sales in 1929, then to the office of president and general manager in 1943, and to the chairmanship of the board in 1952.

Comer D. Hazen, superintendent—engineering and maintenance at Newport Steel Corp., died February 10. Mr. Hazen had been affiliated with the steel industry practically all his life.

Fred O. Reese, metallurgist at Atlantic Steel Co.'s Warehouse Division, died April 6.

Samuel G. Dunning, service consultant of the Reliance Electric and Engineering Co. since 1953, died March 16. Mr. Dunning joined Reliance in 1913. In 1932 he became foreman of assembly and subsequently transferred to the service department, in which he became service manager in February 1949.

Walter A. Fletcher, sales manager of the western division of E. F. Houghton & Co. for the past 14 years, died on April 4.

W. A. Roberts, president of Allis-Chalmers Manufacturing Co. since February, 1951, died April 12. He was 57 years old.

L. E. Emerich, director of marketing for Leeds & Northrup Co., died May 5. He joined Leeds & Northrup in 1922 as a sales engineer, and later managed the San Francisco and Chicago offices. He came to Philadelphia in 1936 as assistant manager of technical sales and later was named manager of that division. In 1951 he became manager of market development and three years later became director of marketing and member of the Leeds & Northrup executive committee.

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(1) Ramming Mixes

A 38-page booklet presenting comprehensive information on the use of ramming mixes for open hearth and electric steel furnaces has been published by the Chemicals Division of Kaiser Aluminum & Chemical Sales, Inc. The publication details instructions for building forms, mixing the basic refractory materials and ramming them. In addition, the booklet provides data on recommended heat-up schedules and material estimating charts, along with drawings and installation photographs to facilitate use of this handy booklet.

(2) Liquid Level Gages

Liquid level gages for indicating, recording, controlling, and telemetering are described in a new 26-page bulletin released by the Bristol Co. Float-type, pressure-type, differential pressure-type, and bubbler-type liquid and water level gages, in strip and round-chart models are shown. In addition information on installing liquid level telemetering and remote control is presented, as well as engineering data on the choice of the proper bulb and instrument for a given installation. (Bulletin L701)

(3) D-c Amplifier

A bulletin describing a new electronic low-voltage linear amplifier designed to increase the speed and accuracy of practically all low level d-c voltage measurements has been published by Hagan Corp. The booklet discusses the construction features, applications, and performance specifications of this new amplifier. (Bulletin MSP-111.1)

(4) Diesel Engine

Heavy duty diesel engines in sizes from 375 to 1000 hp are described in a 20-page bulletin published by Ingersoll-Rand Co. Complete information about the lubrication, cooling and fuel injection systems of the engines, and details about engine housing design, full floating aluminum bearings, large diameter crankshaft, gear driven auxiliaries and other features are included. Also presented are specification and dimension sections and a number of illustrations of the engines and component parts. (Form 10,040)

(5) Cupola Operation

"Operating Practices with the Basic-Lined Cupola" is the title of a new booklet published by Basic Refractories, Inc. The booklet discusses in detail the advantages of the basic cupola operation and explains the mechanics of basic slag systems. Also included is a discussion of lining installation and maintenance procedures, as well as, certain operating difficulties and their corrective measures.

(6) Conduit

National Electric Products Corp., has published a new booklet describing their heavy-duty, rigid steel electrical conduit. Test data sheets compiled by independent testing laboratories which show how the specially protected conduit stands up under the corrosive attacks of salt spray, sulfuric acid, caustic soda, and exposure to excessive heat as compared with another well known conduit are presented in the booklet.

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50	ADALET MFG. CO.	BULLETIN A	Insulating bushings
51	AJAX FLEXIBLE COUPLING CO.		Dihedral spindle shaft couplings
52	AMERICAN FLEXIBLE COUPLING CO.	CATALOG 501 AND BULLETIN 1052	Fully crowned tooth form couplings
53	AMERICAN WHEELABRATOR & EQUIPMENT CORP.	BULLETIN 864	Mechanical descaling process
54	BAILEY METER CO.	SPEC. E65-1 AND E12-5	Analyzer-recorder on combustion economy and chart sample
55	BEARINGS, INC.		Link-Belt mill bearings
56	BEDFORD FOUNDRY & MACHINE CO., INC.		Mill type cranes
57	E. W. BLISS CO.	BULLETIN 40-A	Rolling mills
58	BRISTOL CO.	BULLETIN P1248	Electronic pyrometer controllers
59	BUSSMANN MFG. CO.	BULLETIN FIS AND BULLETIN HCS	Dual-element and hi-cap fuses
60	CHEMICAL CONSTRUCTION CORP.	BULLETIN M102	Gas Scrubber
61	CRANE CO.	FOLDER AD-1942	Diaphragm valves
62	DIAMOND POWER SPECIALTY CORP.		Industrial television
63	DRAVO CORP.	BULLETIN 1301 AND BULLETIN 1304	Crane cab conditioners, Industrial air conditioners
64	DURALOY CO.	BULLETIN 3150-G	High-alloy castings
65	EICHLEAY CORP.		Services to the industry
66	ELECTRIC CONTROLLER & MFG. CO.	BULLETIN 942	Tab-weld plate resistors
67	ELECTRIC CONTROLLER & MFG. CO.	CATALOG 6062	High voltage motor starters
68	ELECTRIC MACHINERY MFG. CO.	FOTO-FACTS NO. 16	Modern motor applications
69	ELLIOTT CO.		Mill motors
70	EXIDE INDUSTRIAL DIVISION, ELECTRIC STORAGE BATTERY CO.	FORM 1982	Motive power batteries
71	FARREL-BIRMINGHAM CO., INC.	BULLETIN 115	Heavy-duty roll grinders
72	D. B. FLOWER MFG. CO.	CATALOG 4-I	Brush holders
73	GAS MACHINERY CO., LTD.	BULLETIN A-105	Wire patenting furnaces
74	GENERAL ELECTRIC CO.	GEA-6204	General purpose recorder
75	GULF OIL CORP.		Super-quench
76	HAGAN CORP.	MSP-111.1	D-c amplifier
77	E. F. HOUGHTON & CO.		Packings
78	JOHNS-MANVILLE CORP.	PK-71A	Oil Seals
79	KOPPERS CO., INC., FAST'S COUPLINGS DEPT.		Detailed descriptions, drawings, etc., on couplings
80	LINK-BELT CO.		Belt conveyor idlers
81	LINTERN CORP.	BULLETIN P-552	Heavy duty air cooled condensers
82	LUBRIPLATE DIVISION, FISKE BROTHERS REFINING CO.		Lubrication
83	MINNEAPOLIS-HONEYWELL REGULATOR CO.	CATALOG 1531 AND CATALOG 9301	Control with electronic instruments, and radiamatic pyrometers
84	MORGARDSHAMMAR	BULLETIN L3-1E	Roller guides in bar or wire rod mills
85	NATIONAL CARBON CO.		Motor and generator maintenance
86	OHIO ELECTRIC MFG. CO.	BULLETIN 112	Magnets and magnet controllers
87	OHIO KNIFE CO.		Slitting
88	PITTSBURGH LECTROMELT FURNACE CORP.	BULLETIN 9	Data on Lectromelt furnaces
89	POST-GLOVER ELECTRIC CO.	BULLETIN 510	Welded steel grid resistors
90	RADIO CORPORATION OF AMERICA		Industrial television in steel mills
91	RAMTITE CO.		Castable and gunning refractories
92	RAMTITE CO.		Steel plant furnaces
93	RUST-OLEUM CORP.		Rust preventive literature and color chart
94	SELAS CORPORATION OF AMERICA		Strip annealing
95	SPRAYING SYSTEMS CO.	DATA SHEET 6120	Descaling nozzles
96	S. G. TAYLOR CHAIN CO.	CATALOG 120	Alloy steel chains
97	UNITED STATES GRAPHITE CO.		Brush catalog
98	WAGNER ELECTRIC CORP.	BULLETIN MU-202	Drip-proof general purpose motors
99	WESTERN GEAR WORKS	BULLETIN 5402	Speed reducers
100	YODER CO.		Cold-roll forming machine

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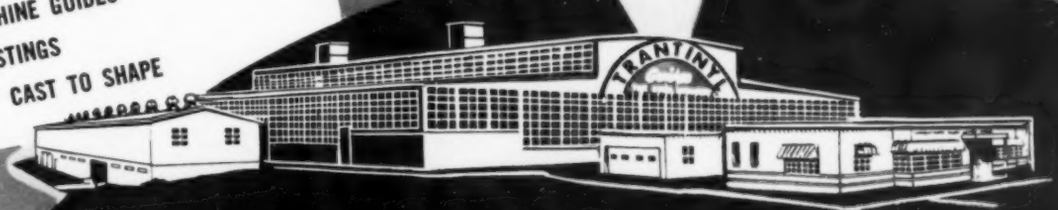
HEAT RESISTING CASTINGS

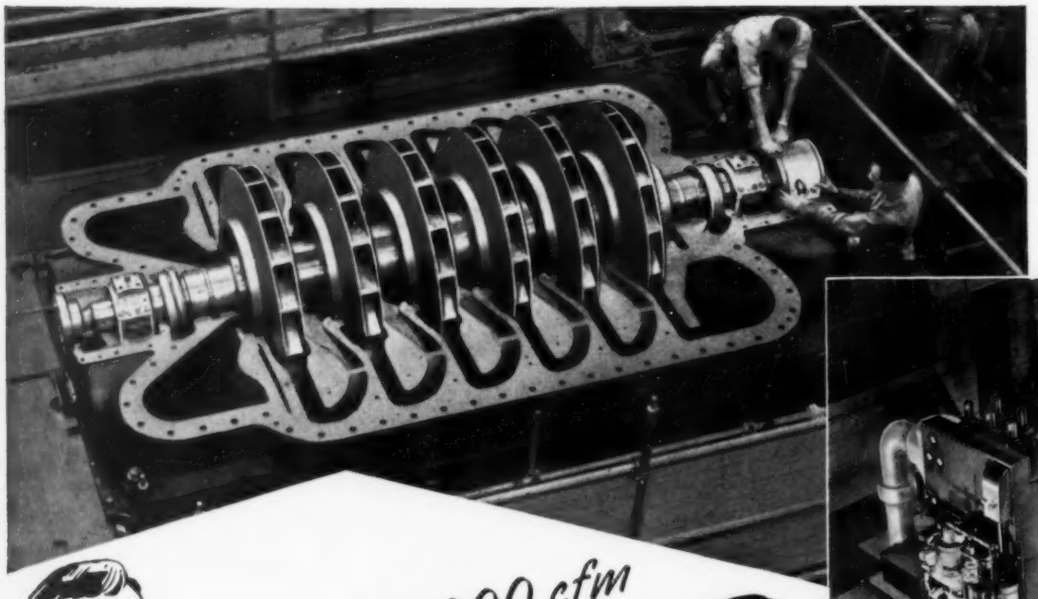
"TRANTINYL No. 1" CAST TO SHAPE



Youngstown Alloy Casting Corporation

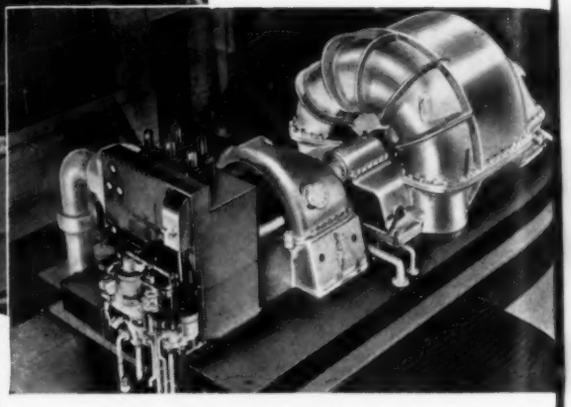
Youngstown, Ohio

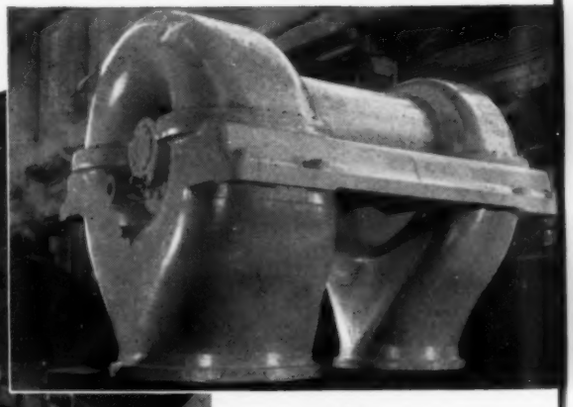
What type BLOWER



Typical centrifugal blower with upper half of casing removed.

75,000-cfm, 30-psig blast furnace blower.





Typical axial compressor of blast furnace size.

Blast furnace type axial compressor with upper half of casing removed.

ALLIS-

for your steel mill?

As requirements move above 100,000 cfm, axial compressor may replace centrifugal blower because of higher efficiency and lower operating cost. Allis-Chalmers experience with both types assures you of sound recommendations.

Battling rising costs, blast furnace designers have sought increased economy through larger blast furnaces. Air requirements of the new units have risen rapidly and have now reached the point where the centrifugal blower is not always the most efficient and economical unit. These are some of the design and operating factors that influence the choice of the best blower for the job:

EFFICIENCY — The axial compressor is inherently more efficient than the centrifugal blower. This is due largely to the fact that the air passing through the centrifugal blower follows a complicated air path, with sharp turns passing from one stage to the next. In an axial compressor, the air path is more nearly a straight line and losses from sharp turns in the air path are avoided.

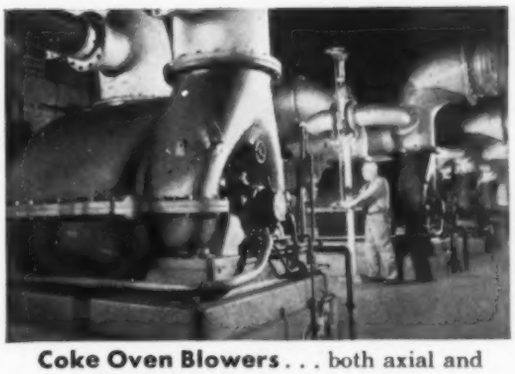
DRIVE UNIT — At 100,000 cfm and above, the speed of a centrifugal blower has dropped below 3600 rpm, while the speed of a comparable axial compressor is approaching 3600 rpm. This difference becomes more pronounced as units get larger. Since the optimum speed of either a turbine or motor drive is about 3600 rpm, the centrifugal makes best use of the drive in smaller sizes, while the axial makes best use of the drive in larger sizes.

SIZE — In all sizes the axial compressor is smaller than a centrifugal blower of the same rating. This means less floor space, smaller foundations, reduced costs.

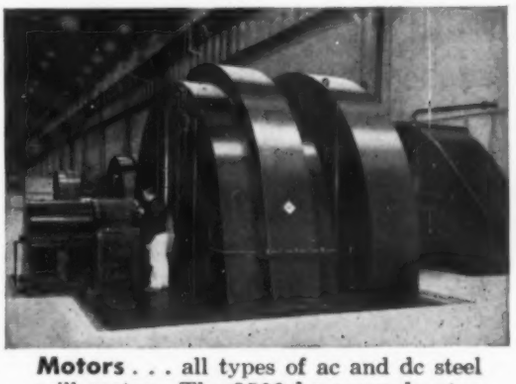
Unbiased Analysis and Recommendations

Since Allis-Chalmers has had wide experience in building both centrifugal and axial types, your Allis-Chalmers representative can help you with your blower problems. Call your nearby Allis-Chalmers District Office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

Other Allis-Chalmers Steel Mill Equipment



Coke Oven Blowers . . . both axial and centrifugal types for booster or exhauster service. Photo shows four 23,000-cfm, 5100-rpm, 35-psig exhausting blowers in western steel mill.



Motors . . . all types of ac and dc steel mill motors. The 3500-hp wound-rotor motor shown is used in conjunction with four 6000-hp synchronous motors driving roughing stands of 80-inch hot-strip mill.

Electric Power Equipment . . . steam turbine-generator units, transformers, switchgear, circuit breakers, rectifiers, control. Shown is a 33,000-kw steam turbine-generator unit with hydrogen-cooled generator supplying power in a modern eastern steel mill.

CHALMERS

A-C ALLIS-CHALMERS

A-4611

THE ELECTRIC FURNACE CO. Salem, Ohio.
EF
Gas Fired, Oil Fired and Electric Furnaces.

HEAT PROCESSING
FURNACES
for the Steel Industry

Equipment for annealing, normalizing, galvanizing and other heat processing of high and low carbon steel, stainless, silicon and other alloys—strip, sheet, wire, tubing and other ferrous and non-ferrous products.

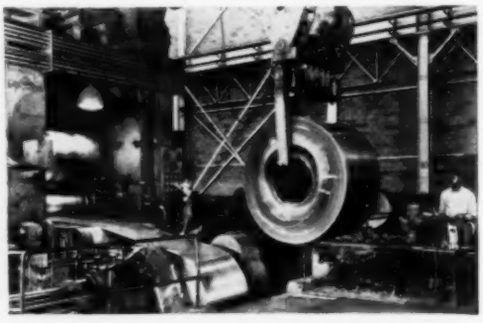
Submit your problems to EF engineers
See our advertisements in preceding and following issues

THE ELECTRIC FURNACE CO.
Salem - Ohio
GAS-FIRED, OIL-FIRED AND ELECTRIC FURNACES
FOR ANY PROCESS, PRODUCT OR PRODUCTION

MANSAVER GRABS®

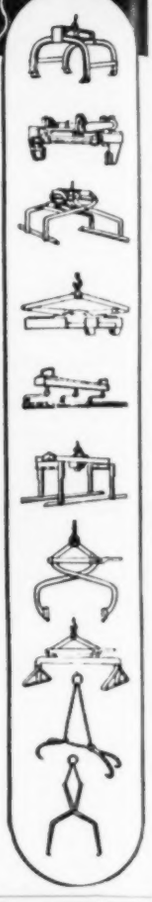
Coils of Various Widths

Mansaver Grab Style G-1418 operates entirely under the remote control of the man at right with no floor assistance. Its motor-driven arms adjust to coils of various widths, take



them safely from storage to mill stands. Supplied with twin suspension (as shown), single suspension, or motor-driven turntable. Mansaver Grabs are supplied for sheet as well.

Write for name of nearest representative.



MANSAVER INDUSTRIES, INC.
3116 EAST ST. • NEW HAVEN, CONN.

The Jones and Laughlin Steel Corporation uses four Gleason Reels for remote control on each of the two shear gauges of the PI-10" Bar Mill in their Pittsburgh Works. Two SHO-102 overhung cable reels shown on the left permit remote control of the travel motors which drive the two traverses. Two LA-76 air hose reels (one out of sight) permit remote control of the gauge stops.

Gleason makes a complete line of spring and motor driven reels in all sizes and capacities. Write for complete details.

Gleason Reel Corp.
Subsidiary of Maysteel Products, Inc.
Room 706
740 N. Plankinton Ave. • Milwaukee 3, Wis.

NOW—ALLOY CHAIN REPAIR SERVICE

in PITTSBURGH and HAMMOND

For greater safety and economy, have your Alloy Sling Chains returned to either our Pittsburgh or Hammond plant for repair, inspection and testing, at nominal cost.

S. G. TAYLOR CHAIN CO., Hammond, Ind.
and 3505 Smallman St., Pittsburgh 1, Pa.

Call or Write **STAMCO** *for...*

Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

ease your
hydraulic equipment
maintenance problems
with
GULF
HARMONY
OIL

Use a hydraulic oil that has excellent resistance to oxidation, high film strength, outstanding rust preventive and anti-foam properties—qualities which hydraulic engineers consider to be the most important when selecting a hydraulic lubricant —and you will have fewer maintenance problems and less down time.

Gulf Harmony Oil has all of these qualities. It prevents the formation of sludge deposits and maintains its original viscosity over long periods of time. It also protects hydraulic equipment against excessive wear, even under severe conditions of pressure, speed, and temperature. And it protects against the damaging effects of harmful rust.

So if you have maintenance problems with your hydraulic equipment, call in a Gulf Sales Engineer. He will recommend the right grade of trouble-preventing Gulf Harmony Oil for your equipment. Contact him today at your nearest Gulf office.

GULF OIL CORPORATION
1822 Gulf Building

GULF

GULF REFINING COMPANY
Pittsburgh 30, Pa.

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

IMPROVE YOUR THIRD

with

BOOST SAVINGS IN ENGINEERING, EQUIPMENT,

PETTICOAT INSULATORS FOR THIRD RAIL SERVICE TO 4160 VOLTS

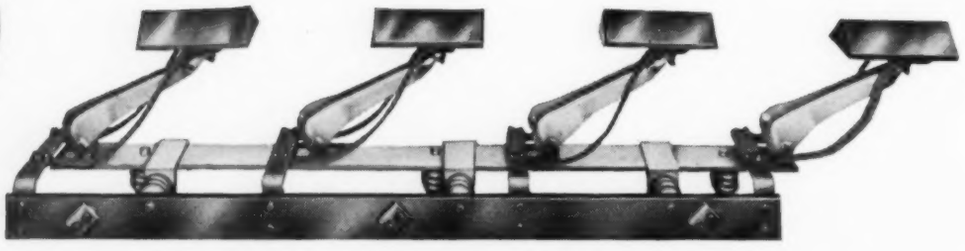
HIGH MECHANICAL STRENGTH, with tensile and cantilever properties for heavy-duty over or under-running applications. Extra heavy petticoats to stand industrial abuse.

QUALITY MATERIALS, using high grade wet process, glazed porcelain to assure permanent efficiency.

UNSURPASSED ELECTRICAL PROPERTIES, with extra leakage distance and self cleaning surface to lessen effect of contaminations leading to shutdowns. Petticoat insulators also recommended for dirty low voltage systems.

ALL PURPOSE HARDWARE available for rail, angle or wire service.

NEW



COLLECTORS FOR UNDER-RUNNING CONTACT SYSTEMS

HIGH AMPERAGE . . . collector arms used in multiple units for high capacity (2400 amp. shown).
DEPENDABLE . . . contact surface protected against sleet and dirt; bearings sealed against grit.
LONG LIFE, HEAVY DUTY . . . vital parts are stainless steel; contacts are extra large.
NON-ARCING BEARINGS . . . integral insulating bushings insure current transfer through shunts.
WIDE OPERATING RANGE . . . will accommodate vertical and horizontal misalignments.

ELECTRIC SERVICE MFG. CO.

RAIL INSTALLATIONS

KEYSTONE PRODUCTS

INSTALLATION, MAINTENANCE AND PRODUCTION

STRAIN INSULATORS FOR CRANE BRIDGE ANGLES

This new insulator now TOPS in the field.

- **SMALLEST SIZE: 2" diameter; accommodates smaller angles and permits closest conductor spacings.**
- **FUNCTIONAL SHAPE: small end provides extra clearance for collector.**
- **LONGER LEAKAGE DISTANCE: reduces possibility of shut-downs due to contamination.**
- **INSULATORS COST LESS than wooden supports.**
- **STEEL INSULATOR INSERTS are free of shrinkage . . . never vibrate loose.**
- **HIGH STRENGTH — tensile and cantilever — minimizes breakage.**
- **STRAIN HARDWARE available for all insulators.**

XVE *"Econo-Mizer"* CRANE COLLECTOR FOR PICK-UP WIRE SYSTEMS

The XVE "Econo-Mizer" crane collector. Includes all advantages of strain insulator above, plus . . .

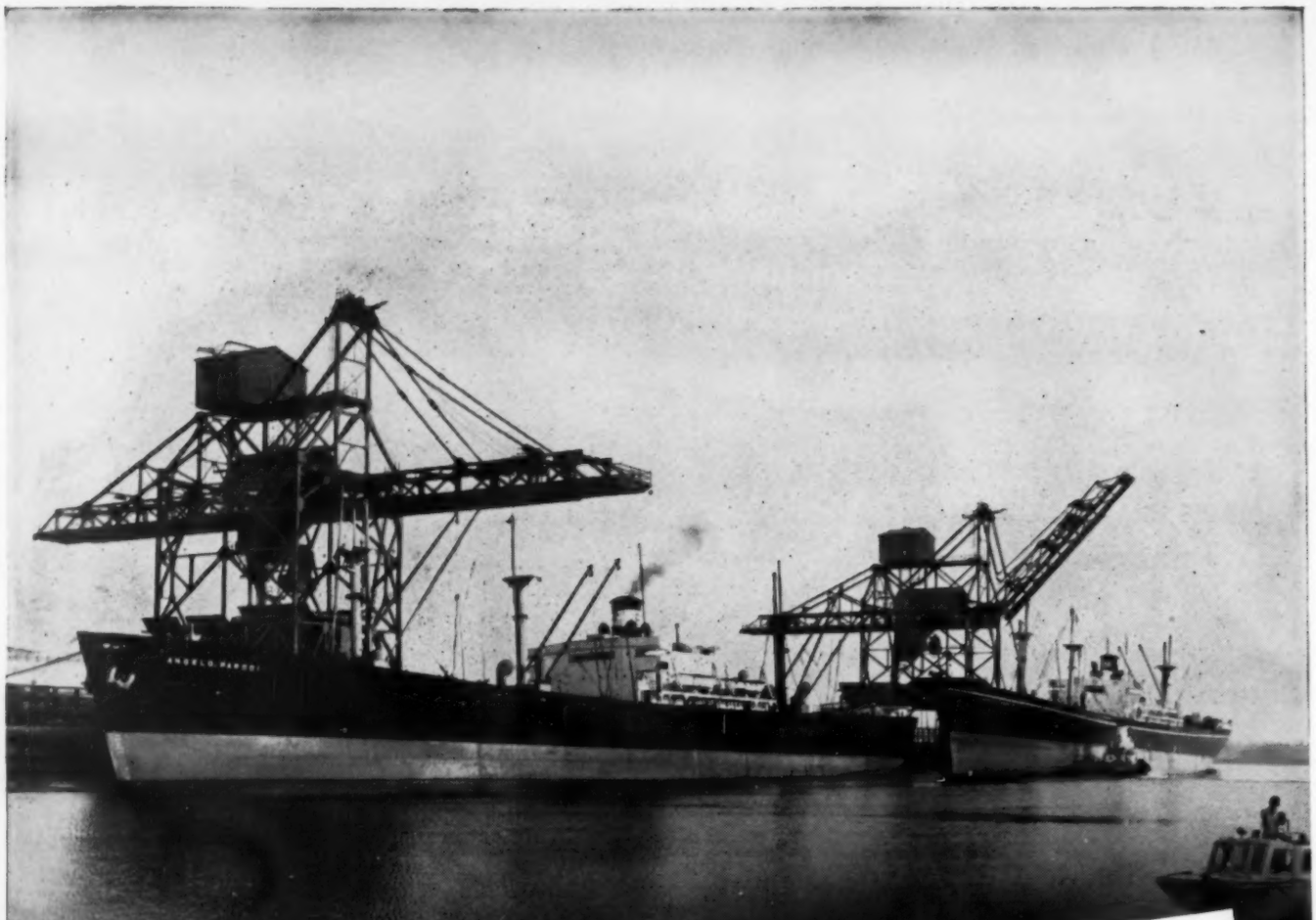
- **NEW LOW COST: entire assembly costs less than castings alone for other type collectors.**
- **MULTIPLE SAVINGS: replacement of complete body assembly is quicker . . . easier . . . cheaper than repairing.**
- **LONGER SERVICE: carbon contacts give greater life and reduce arcing. Graphite lubrication prolongs wire life.**
- **INTEGRATED CONTACT electrically bonded to collector body for uniform efficiency; shaft is permanent part of insulator.***
- **COMPACT: designed for closest wire spacings.**

***Collector also available without insulator.**

Photo: Actual Size

Write for details on these third rail system improvements

Philadelphia 32, Pa.



These two man trolley type unloaders, built by Dravo Corporation, are part of the materials handling equipment at the dock of United States Steel Corporation's new Fairless Works near Morrisville, Penna.

The two unloaders run parallel on a common runway for a distance of 1,000 feet. Each unloader is built to handle a 200-cu. ft. ore bucket or a 400-cu. ft. coal bucket. Coal or ore can be unloaded to railroad cars, to pit storage or to a conveyor belt.

DRAVO

DESIGNERS *and* BUILDERS

BRIDGES AND UNLOADERS • TOWER-TYPE UNLOADERS
FLOATING CRANES • DRAVO RAIL CLAMPS
MODERNIZED TROLLEYS FOR EXISTING BRIDGES
WHIRLER CRANES • BARGE SHIFTERS
HYDRAULIC BUFFERS

Why not make use of Dravo's more than 60 years of practical experience in the engineering field when planning your next heavy materials handling project?

DRAVO
CORPORATION

NEVILLE ISLAND, PITTSBURGH 25, PENNSYLVANIA

AIR CONDITIONING • BOILER AND POWER PLANTS • CRANE CAB COOLERS • DOCKS • INDUSTRIAL FOUNDATIONS • OPEN STEEL FLOORING
PUMP HOUSES AND INTAKES • SPACE HEATERS • WATER AND WASTE TREATMENT PLANTS • TOWBOATS AND BARGES

Equipment News...

RAMMER

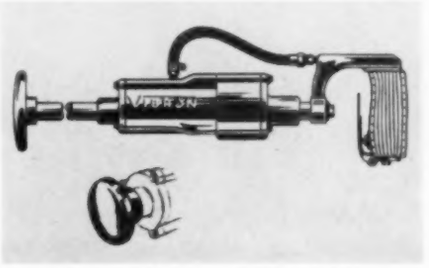
▲ A new pneumatic rammer manufactured by the Vibron Division of the Burgess-Sterbentz Corp., can cut to a minimum the downtime for the application and the patching of refractories.

Light and easy to handle, the rammer delivers a controlled, powerful, recoiless stroke. Recoil shock and vibration elimination add to worker efficiency through the reduction of fatigue, and permit important increase in the "ramming hours" per day.

In addition to increased efficiency, the recoiless features result in safer operation. The elimination of severe vibration and kick-back protect the workers from discomfort and physical injury.

The rammer is specifically designed for greatest possible utilization for all types of refractory ramming. Designated as the Model G-162D, the rammer has twin rubber grip handles for better control and operation. The rear grip handle can be rotated on the mounting for better positioning of the rammer and greater ease of control and operation. The front grip houses the trigger and is located under the center of balance for one-hand operation.

Made of a bronze lined alloy aluminum body, the rammer is precision fitted with a hard chrome piston to insure dependable, trouble-free service. The rammer itself is designed so



that its maintenance is held to a minimum cost by the elimination of costly seal and bearing replacement.

The rammer operates at the usual shop air pressure on the exclusive and highly efficient Vibron cycle and therefore uses little air. A quick-connect coupling is furnished to permit simple and rapid connection of the easy-to-manage ¼-in. air supply line to the rammer.

Normally supplied with a circular ramming head three in. in diameter, the rammer can be equipped with shafts of varying length and heads with larger or smaller diameters or irregular shapes, depending on the requirements of the work.

MASONRY SAW

▲ Introduced by the Robert G. Evans Co., is a full-size masonry saw in the low price field. A dual voltage switch that converts the 1½ hp motor from 110 to 220 volts is standard equipment on the saw.

Other features are the totally enclosed motor, the cutting head, the saw frame and the conveyor cart. The angle-set mechanism permits the operator to angle the cutting head from any size material, for any kind of cut. The cutting head is removable in two seconds for instant portability.

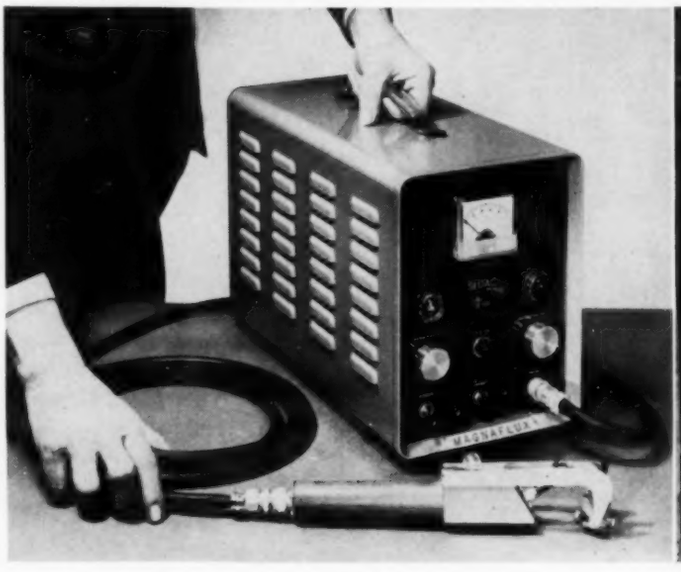
BRAZING UNIT

▲ Selas Corp. of America has developed a new self-contained, gas-fired packaged unit for fast, dependable automatic brazing.

The packaged unit uses precise control of combustion and automatic timing to produce sound brazed

LIGHTWEIGHT ELECTRONIC UNIT MEASURES SURFACE DEFECTS

A portable electronic instrument that can non-destructively detect and measure the depth of cracks in iron and steel has been announced by Magnaflux Corp. Known as Sedac SE-100, the device will locate and measure the depth of defects from 0.012 to 0.120 of an in. deep. Larger cracks are detected but their size over 0.120 in. is not measured. By comparison with the known sample provided the instrument can be calibrated to find only cracks deeper than a pre-selected allowable minimum. It can be used on flat pieces and curved surfaces with a 3½ in. or larger radius.



REFRACTORY CEMENT

- BONDS STRONGER
- LASTS LONGER

For Example-

In Blast Furnaces—Because of its practically iron-free composition, Super #3000 shows exceptional resistance to carbon deposition and alkali attack. This plus its volume stability and great abrasion resistance make it the strongest refractory mortar for blast furnace work.

In Butt Weld Pipe Furnaces—Resetting fire brick arches and wash coating with Super #3000 has provided continuous service for many months, whereas other mortars failed in 5 to 6 weeks.

In Coke Ovens—Repairing floors while still hot with Super #3000 has saved one plant $10,000 in maintenance in a few months.

There are a great many more reports of Super #3000 success—where other refractory mortars have failed quickly and utterly—in furnace walls, arches and floors, soaking pits, sinter towers, ladle linings, etc. Users call it the "Wonder Cement." Try it—you'll agree.

REFRACTORY & INSULATION CORP.

R&I

REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS

136 WALL STREET • NEW YORK 5, NEW YORK

joints of uniform high quality at high speed. Simple joints in small parts may be brazed by one unskilled operator at rates as high as 500 assemblies per hr.

All equipment is rigidly mounted on an integral structural steel frame. This equipment includes a combustion controller to deliver fuel/air mixture at a predetermined ratio and pressure; fully adjustable burners to provide the optimum heat pattern and heating rate; permanent or replaceable fixtures to support the work components; a dial-type worktable to carry the assembly past the burners in continuous or intermittent motion; and all the necessary automatic timers, pneumatic indexing equipment and electric motors. Provision may be made for specialized functions such as automatic feed and delivery and air- or water-controlled cooling. Installation requires only setting the machine in place and making connections to normal shop utilities.

Although this design provides considerable versatility for general brazing operations, each automatic brazing machine is engineered to meet a range of jobs as specified by the user. Specific details of design are based on laboratory research, and each machine is tested in actual operation before shipment.

FLOW TRANSMITTER

▲ A new force balance flow transmitter that measures differential pressures and transmits a 3-15 psi signal to a receiving, recording or controlling instrument has been announced by the Foxboro Co.

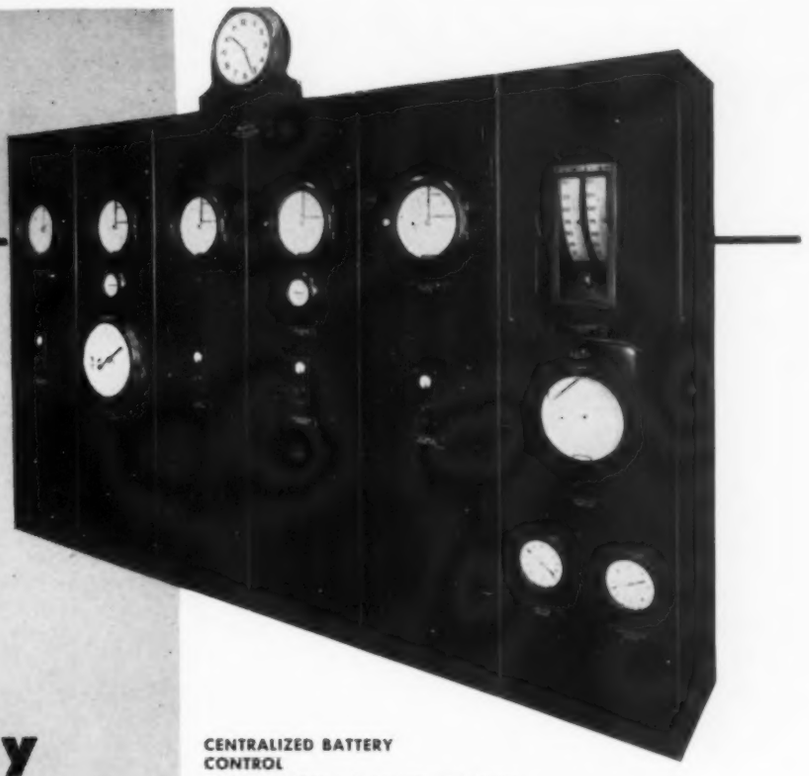
The new transmitter provides continuous adjustment over the entire range of 0-50 to 0-250 in. of water differential without change of parts.

Unitized "block" construction of the three basic parts—body, transmitter and air relay—eliminates the effects of piping stresses. Operating on the force balance principle, the all-metal measuring components and temperature-stable parts such as the Elgiloy stainless alloy sealing diaphragm, maintain calibrated accuracy over a wide range of ambient conditions.

A silicone-filled capsule, with two pressure-sensing Type 316 stainless steel diaphragms, automatically dampens and filters flow "noises" at

Newest

REPUBLIC CONTROLS installed on coke battery



CENTRALIZED BATTERY CONTROL
at this panel permits an operator to coordinate automatic regulators controlling stack draft, fuel gas volume and pressure and blast furnace gas pressure. Gages and regulators monitor the system.

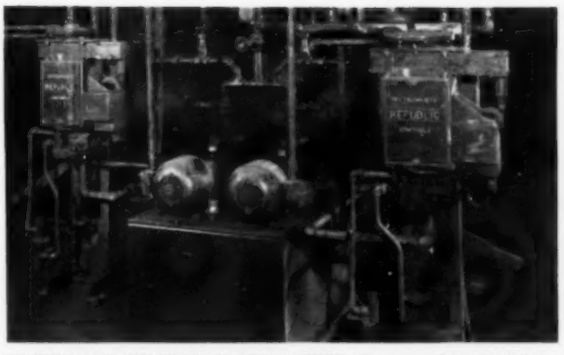
When a new coke battery was added to the coke plant of a mid-western steel mill, Republic electrically controlled hydraulic regulators were installed to control the additional capacity. These new type regulators supplement Republic-Smoot regulators which have been in operation on some of the older batteries for more than 34 years. Dependability, the determining factor in the selection of the new equipment, was more than proven by the performance of the older controls.

The same features—ruggedness and simplicity—which kept these controls in continuous service year after year are embodied in modern Republic Instruments and Controls. That's why Republic equipment remains dependable, regardless of dirt, heat, shocks and vibration. It's also why steel mills such as this one specify Republic, again and again.

GET ALL THE FACTS ABOUT REPUBLIC INSTRUMENTS AND CONTROLS FOR STEEL MILLS

- **ELECTRIC FLOW METERS** for continuous integration and fast transmission of flow information
- **PNEUMATIC ELECTRIC FLOW METERS** for oxygen scarfing and dirty gases
- **LOW PRESSURE RECORDERS** for open hearths, soaking pits, coke ovens, reheating furnaces, smelting furnaces
- **HIGH SPEED POSITIONING OPERATOR** for furnace doors
- **FURNACE PRESSURE REGULATORS**
- **FLOW REGULATORS**
- **BTU TOTALIZERS** for more efficient operation of open hearth furnaces

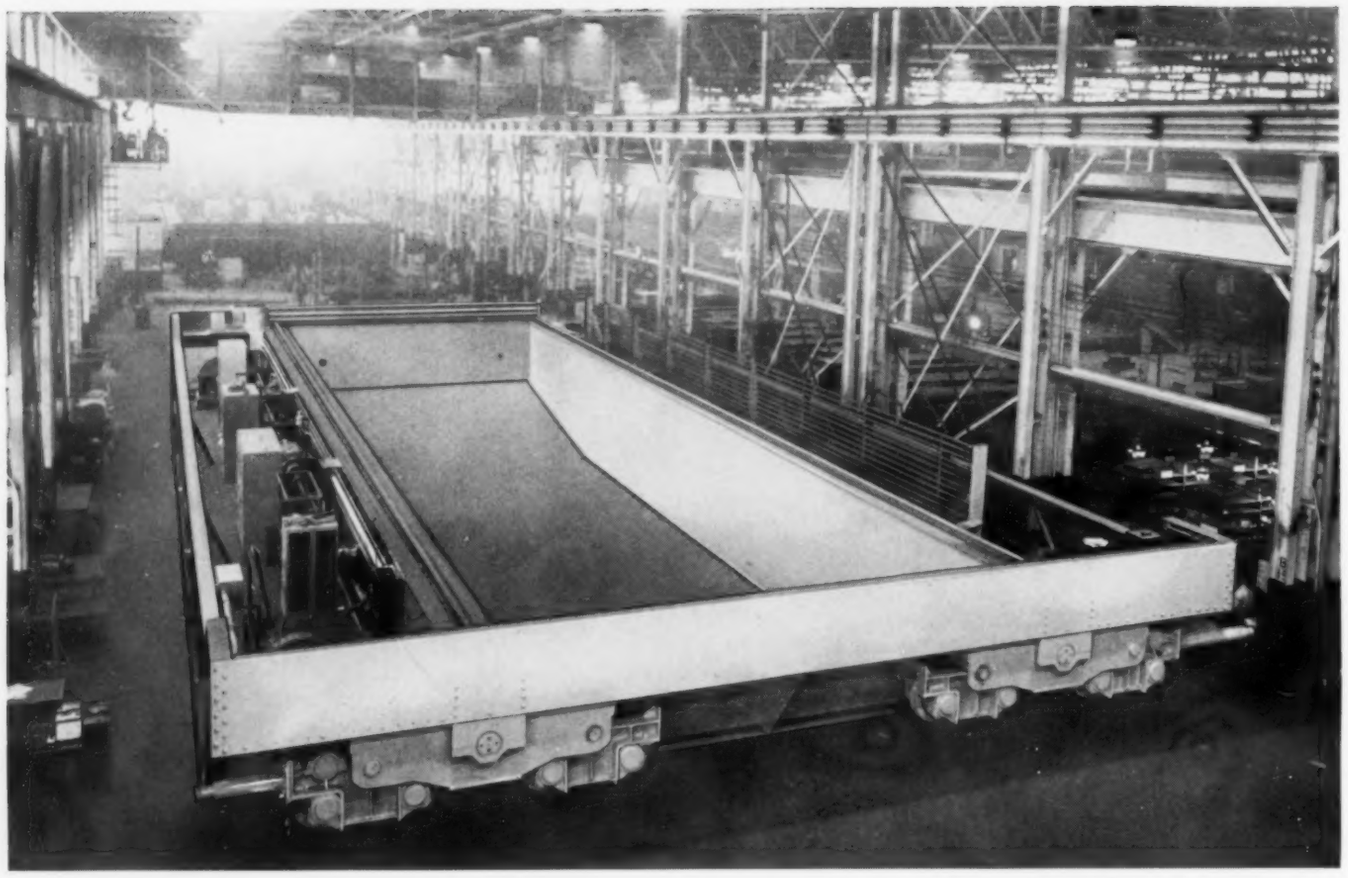
Write for literature on any of the above



ELECTRICALLY CONTROLLED REGULATORS. The control point of these Republic hydraulic type regulators is set electrically from control panel. In case of failure of hydraulic system, oil trapping valve will lock the regulators in their last position before failure. Electrical failure or accidental shorting of the transmission lines will not cause regulators to shift their control setting.

STILL IN SERVICE AFTER 34 YEARS. These old type Republic-Smoot regulators were installed in 1919 when the coke batteries were built. They operate on the force-balance principle, which permits strong, durable construction without loss of accuracy or sensitivity. This same operating principle is used in modern Republic regulators and pneumatic transmitters.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois



CRANES TO A.I.S.E. SPECIFICATIONS No. 6....

by "Shaw-Box"

Since the issuance of A.I.S.E. Standard Specifications No. 6 covering steel mill cranes, "Shaw-Box" has built many cranes ranging from 10 to 200-tons to these specifications. The above illustration, showing a 175-ton capacity bridge 80'-0" span with double bridge drive and double equalized trucks, is typical of their interpretation of these specifications.

In "Shaw-Box" Steel Mill Cranes, whether built to A.I.S.E. Specifications or your own, you get the added advantages that come from the experience gained in more than 65 years of building exclusively overhead load-handling equipment, plus "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. You also obtain today's greatest value in steel mill cranes.

SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

MANNING MAXWELL & MOORE MM&M TRADE MARK

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.
Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments, and Aircraft Products.

the measurement source, yet permits high speed response to actual flow. New also are machined overrange stops for protection up to full 1500 psi rating of the instrument.

A convenient external zero adjustment permits the transmitter to be zeroed without removing weatherproof housing. The unit weighs only 21 lb; is compact for close coupling to orifice flanges.

HIGH SPEED SHEAR

▲ A high speed shear for automatically shearing 1¼ in. plates, 12 ft wide and 40 ft long has been designed by Stamco, Inc.

Each shear stands approximately 19 ft high and weighs approximately 275,000 lbs. Each of the clutches on these shears weighs approximately 10,000 lbs including the flywheel. The two side cut shears and the end cut shear are each driven by a 60 hp motor.

Several new features are included in these shears. An endless belt conveyor between the side cut shears is used to feed or progress the plates through the side cut shears and to hold these plates during the shearing cycle. Also when side trimming long plates, the scrap is sheared completely off automatically before the plate is progressed. This is accomplished by utilizing a short pair of shear blades set at 45 degrees to the regular blades and at the end of the cut.

HERE'S THE USG® BRUSH THAT DOES AN OUTSTANDING JOB ON ALL YOUR MILL MOTORS

When you replace the brushes on your mill motors, you can get the best results with U S G Grade 135 Brush with Statite®. For brushes that give superb results in other applications, see below. Write for your copy of the complete U S G Brush catalog today.

A typical U S G Grade 135 Mill Motor Brush with Statite*

U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade AH897 Brush for Welding generators with Statite*

U S G Grade 1658 Brush for tin line collector rolls

U S G Grade 550 for AC Crane Motor Rings

*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

203

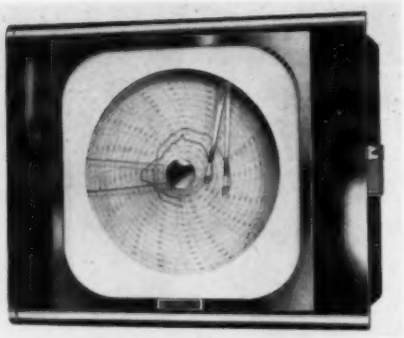
THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

RECORDER

▲ Announced by the Bristol Co., is a two-pen round chart dynamaster potentiometer recorder that can make two continuous records at the same time on a 12-in. round chart.

In many applications, records of two related measurements must be closely compared with respect to the magnitude and time of any variations from the desired value. With both records on the same chart, such comparison is simpler and more accurate than when two separate charts must be studied.



The potentiometer and bridge instruments can be used to measure and control any variable which can be translated into an electrical quantity, such as temperature, pH, consistency, speed, pressure, weight, and others.

MOTORS

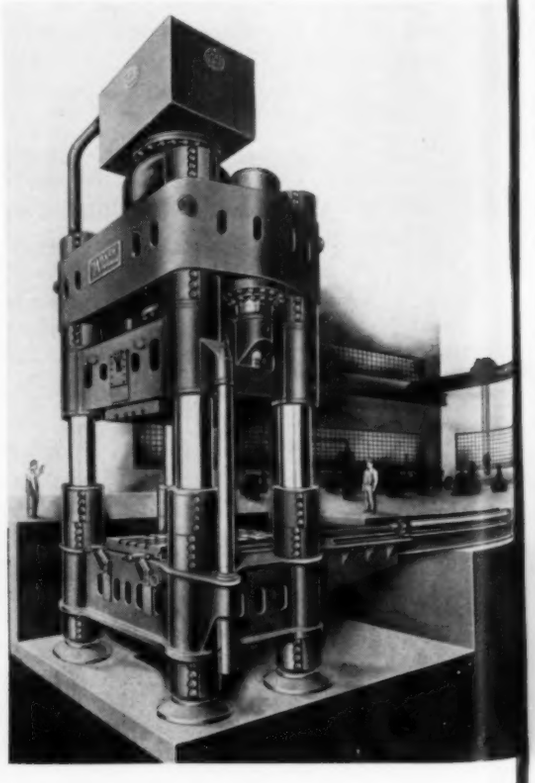
▲ Announced by Wagner Electric Corp., is a new line of general-purpose ball bearing polyphase motors in re-rated NEMA frame sizes 182 through 326.

These DP motors with corrosion-resistant cast iron frames are suitable for indoor or outdoor use. Frames are smoothly contoured so that moisture cannot collect on their surfaces and construction is so completely drip-proof that the motors can be used for many applications formerly requiring splash-proof motors.

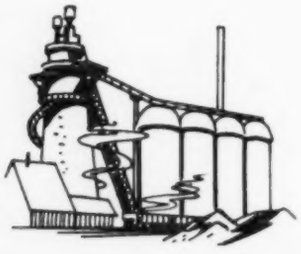
To protect motors from moisture, ventilating air intakes are located at the bottom of the endplates and air outlets are positioned at the base

FORGING PRESS

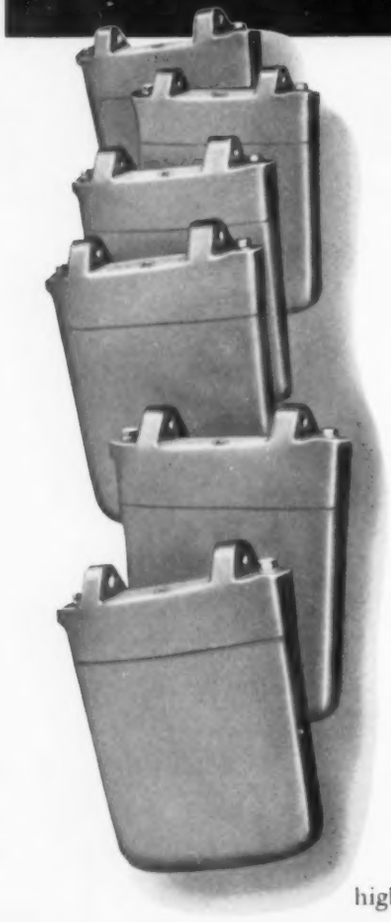
This 8000-ton hydraulic forging press is one in a battery of new presses being installed at the Harvey Aluminum plant in Torrance, Calif. A part of the Air Force Heavy Press Program, the machine is extremely rigid in design, will restrict full load deflection to a minimum, and will accommodate complex unsymmetrical forgings. The 8000-ton press is over 50 ft in height. It is equipped with top and bottom ejector mechanisms and will have an effective die bed of 110 in. by 70 in. Other features are the 110-in. daylight and the 72-in. stroke.



Lawrence
COPPER COOLING PLATES



for your NEXT CAMPAIGN



If faulty cooling plates are giving you trouble, replace them with Lawrence Copper Bosh or Mantle Plates.

Lawrence Cooling Plates, made from pure copper with the know-how gained from 67 years in serving many of America's large steel plants, are your assurance of dependable, trouble-free performance throughout the campaign.

Send us your specifications today. We are at your service.

PURE COPPER CASTINGS
Tuyeres • Tuyere Coolers
Cinder Notches
Valve Gates and Seats

BRASS AND BRONZE CASTINGS
(Heavy type — 1 to 2 ton)
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highest *Quality & Dependability* since 1888

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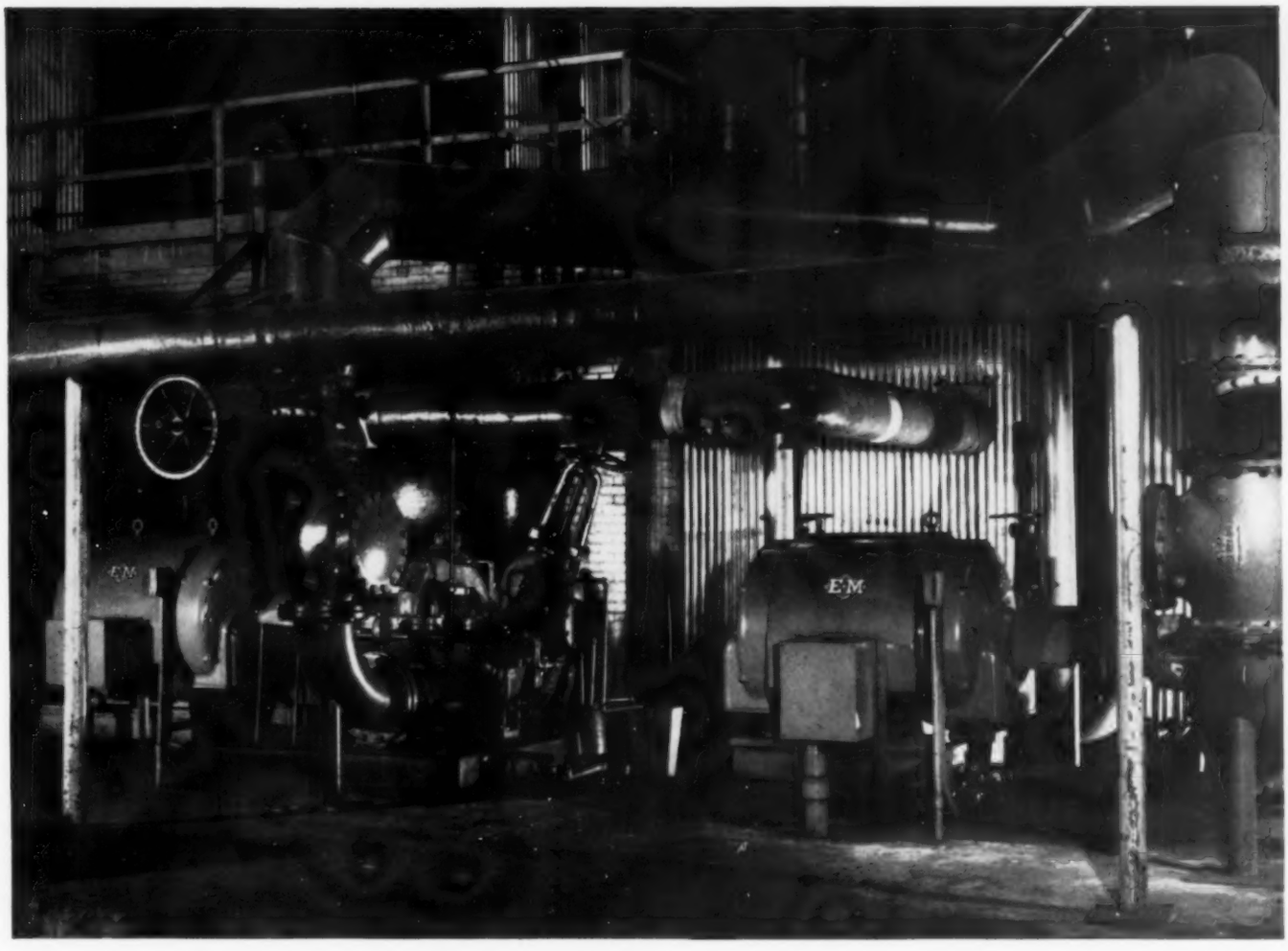


Jones & Laughlin Steel Corporation enjoys low maintenance costs on large motor drives

● Safeguarding motor operation in a steel mill is an important factor in the mill's over-all profitable operation. Motor shut down means costly maintenance projects and large production losses. Bearing failures and winding burn outs are no longer considered inevitable, and today's mill operators who are interested in continuous high-level production are taking advantage of modern motor design to insure against motor failure.

The two 400 hp, 1450 rpm, splash-proof E-M Squirrel-Cage Induction Motors above show how Jones & Laughlin Steel Corporation engineers use modern motor design to protect against motor outage. These motors, which drive centrifugal pumps supplying water to three hot strip-mill furnaces at the Pittsburgh works, have given year-in, year-out service with only routine bearing lubrication and inspection. E-M *Protective Construction* keeps water and foreign material out of vital parts, so essential to uninterrupted, trouble-free operation.

And remember, *Protective Construction* means more than physical shielding of windings and bearings with splash-proof or other protective enclosures. It includes the E-M "know-how" of motor design and special attention to the smallest details of construction. Here are some of the important features in E-M *Protective Construction:*

1. Windings custom designed for the application, repeatedly processed to keep moisture out.
2. Coil ends methodically lashed to heavy rings to prevent movement during repeated starting surges.
3. Bearings precision engineered and processed for cool, long-life service.
4. And rotors of practically indestructible cage construction, accurately balanced for vibration-free operation.

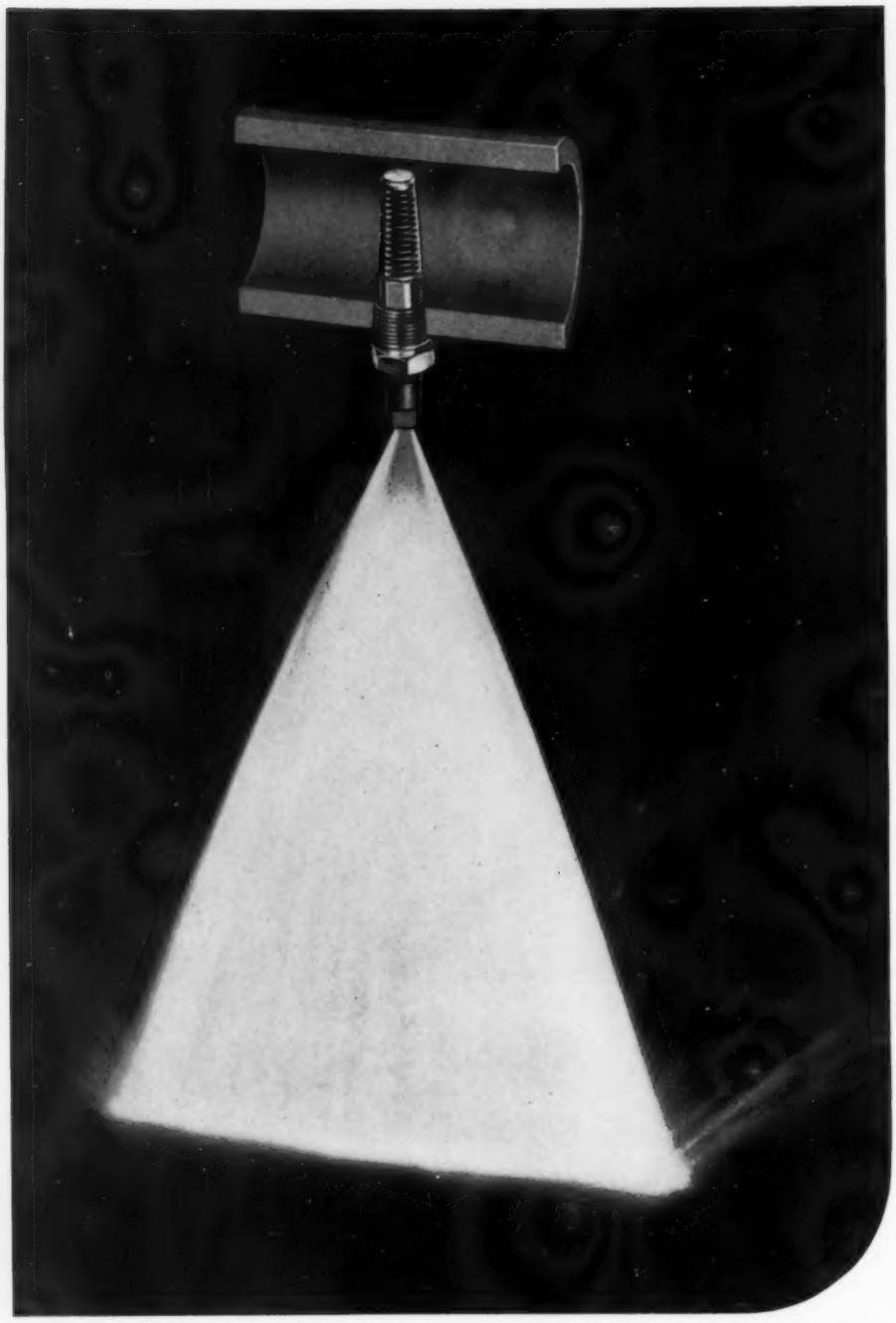
For your next *special* motor application call on your local E-M sales engineer for helpful counsel. Let him show you how E-M *Protective Construction* can help keep your maintenance costs low on large motor drives. And write the factory for E-M Foto-Facts No. 16, showing other modern motor applications in a modern steel mill.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

1300-TPA-2167

Specialists in making motors do **EXACTLY WHAT YOU WANT THEM TO**



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descaling NOZZLES

with open, elliptical non-clogging orifice

for performance *in full measure*

you can SEE the difference

When you consider performance in all its aspects, here are spray nozzles for descaling that give outstanding full measure. Descaling itself is carried out with an efficiency as high as or higher than any other nozzle made. But equally important, Spraying Systems nozzles give you low first cost . . . **plus non-clogging design** that **reduces** the cost of down-time and maintenance to a minimum.

The thin, concentrated, uniform spray strikes with greatest possible impact for any volume and pressure . . . descales without excessive sheet cooling.

Clogging is practically eliminated by *elliptical*-shaped orifice . . . foreign matter goes right through.

CHOICE OF SIZES . . . offered in 16 different capacities . . . for every known descaling use.

Designed and manufactured by America's leading producers of industrial spray nozzles. For complete information write for Data Sheet 6120.

SPRAYING SYSTEMS COMPANY 3262 Randolph Street • Bellwood • Illinois

Spray Nozzles also supplied for such applications as Run-Out Table Cooling . . . Roll Cooling . . . Cooling Ingot Molds and many other uses. For complete information write for Catalog No. 24.

Specify Adalet for

Sali insulating bushings

Assure trouble-free wiring of:

- conduit runs
- outlet boxes
- electronic equipment
- control cabinets
- switchboards

Precision machined from phenolic material, NEMA Class XX, Adalet insulating bushings are available for pipe sizes from ⅛ inch through 6 inches. Can be used on rigid or thin-wall conduit terminals, junction boxes, control cabinet knockouts, etc.

Mechanically and dielectrically strong . . . moisture and oil resistant. Send for sample or:

Request Bulletin A

THE Adalet MFG. CO.
14300 LORAIN · CLEVELAND 11, OHIO

of the frames on each side. Specially formed baffle plates direct air into the blowers and through the motor and also provide extra protection for the stator windings.

The units will be available in 1 to 30 hp ratings, 3 phase, 60 cycles, 1750 rpm.

EMULSION CLEANER

▲ A new emulsion cleaner for ferrous and non-ferrous metals has been introduced by the Brooks Oil Co. "Rollene E.C." was developed for removing foreign substances from metal sheets prior to processing of finished product in stamping plants.

It removes any foreign substance that may cause damage to product or equipment — such as grit and dirt, fine metal particles from shearing or blanking and other contamination picked up in handling.

The material is used in circulating systems and is readily soluble in hot or cold water. A 9 to 1 solution with tap water makes a stable cleaning solution.

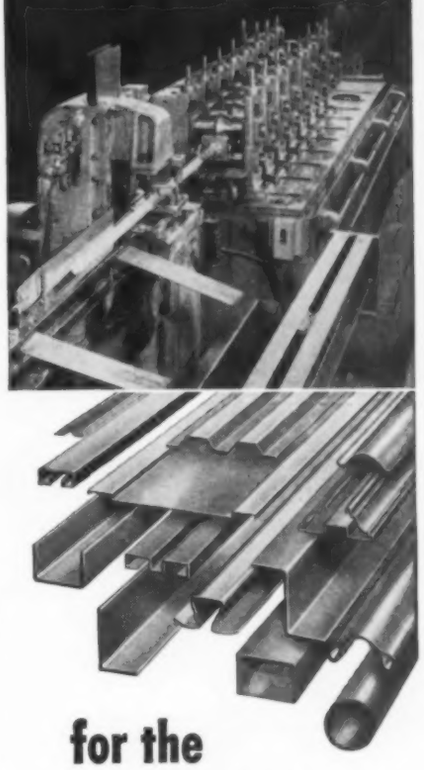
The emulsion cleans by a penetrating action, creeping under foreign material and floating it away. The film is deposited on the sheet which is non-corrosive and acts as an aid in drawing operation. The nature of the material eliminates roll slippage on press feeders, reducing loss of steel caused by short lengths. Non-toxic and non-corrosive, "Rollene E.C." eliminates fire hazards by means of its high flash point—assuring safe inside storage and use.

The manufacturer states that low cost initial installation together with minimum amount of make-up; produces low cost per ton cleaning. The material also is said to eliminate messy and unsafe floor conditions in the work area, and has low organic acidity which will not increase in storage.

On a small system of 150 gallons, approximately 50 gallons of solution make-up is required every 24 hours —involving only the addition of several gallons of "Rollene E.C." to 50 gallons of water.

According to the manufacturer, the emulsion has been proved more economical than process oils. A comparison test—using "Rollene E.C." in two lines and process oil in two similar lines—showed the cost per ton of

COLD-ROLL-FORMING



for the Growing Business

● As your business grows, new opportunities arise for drastic cost reduction through the use of cold-roll-formed parts or finished products. Decorative metal mouldings is only one of a great many things you can make with a Yoder cold-roll forming machine.

You can, for instance, make structural angles, channels, etc., up to ½ in. thick. You can form wide sheets or panels into cabinets for refrigerators, ironers, lockers, radio and TV sets, etc. You can make virtually all the components for metal buildings, including trusses, joists, studs, siding, roofing, windows, and doors.

You can, in addition, do perforating, notching, embossing, coiling, curving, welding, etc. Sections can be cut to length and ends given almost any shape, plain or fancy, by means of one or two Yoder automatic cut-off machines synchronized with the forming machine.

The Yoder Book on Cold-Roll-Forming is a valuable source of information on the scope, mechanics and economics of the art. Send for free copy.

THE YODER COMPANY
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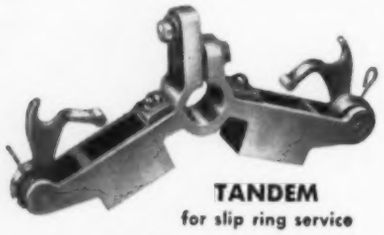
Cold-Roll FORMING MACHINES
ENGINEERING YODER MANUFACTURING

MAXIMUM
motor and
generator
PERFORMANCE
with

FLOWER

BRUSH HOLDERS



TANDEM
for slip ring service

TYPE 85-SK
for stationary motors
and generators

There's a reason for the claim: "maximum motor and generator performance" – long life for both Brush Holders and Brushes is built into the units with highest quality bronze castings, precision machining – proper designing.

Known throughout industry for their enduring qualities, some of these units have lasted more than 24 years, under critical operating conditions. High resistance to vibration and wear assures you, your FLOWER BRUSH HOLDER will not cause breakdowns in production.

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FLOWER PHILADELPHIA

D. B. FLOWER MFG. CO.

1217 Spring Garden Street, Phila. 23, Penna.

steel with "Rollene E.C." to be 75 per cent under that for process oil.

SOLENOID VALVE

▲ C. B. Hunt & Son, Inc., has improved its "O"-type solenoid valves by changes that are said to effectively protect all operating parts from the entrance of dust and grit.

A sintered bronze filter is now provided in the breather hole of the spring cap. This filter, which consists of small bronze particles pressed together into a porous mass, permits air to pass through the filter in either direction, but prevents the entrance of dust or grit which under adverse conditions might tend to build up sufficiently to interfere with the proper action of the return spring or work into the internal valve parts.

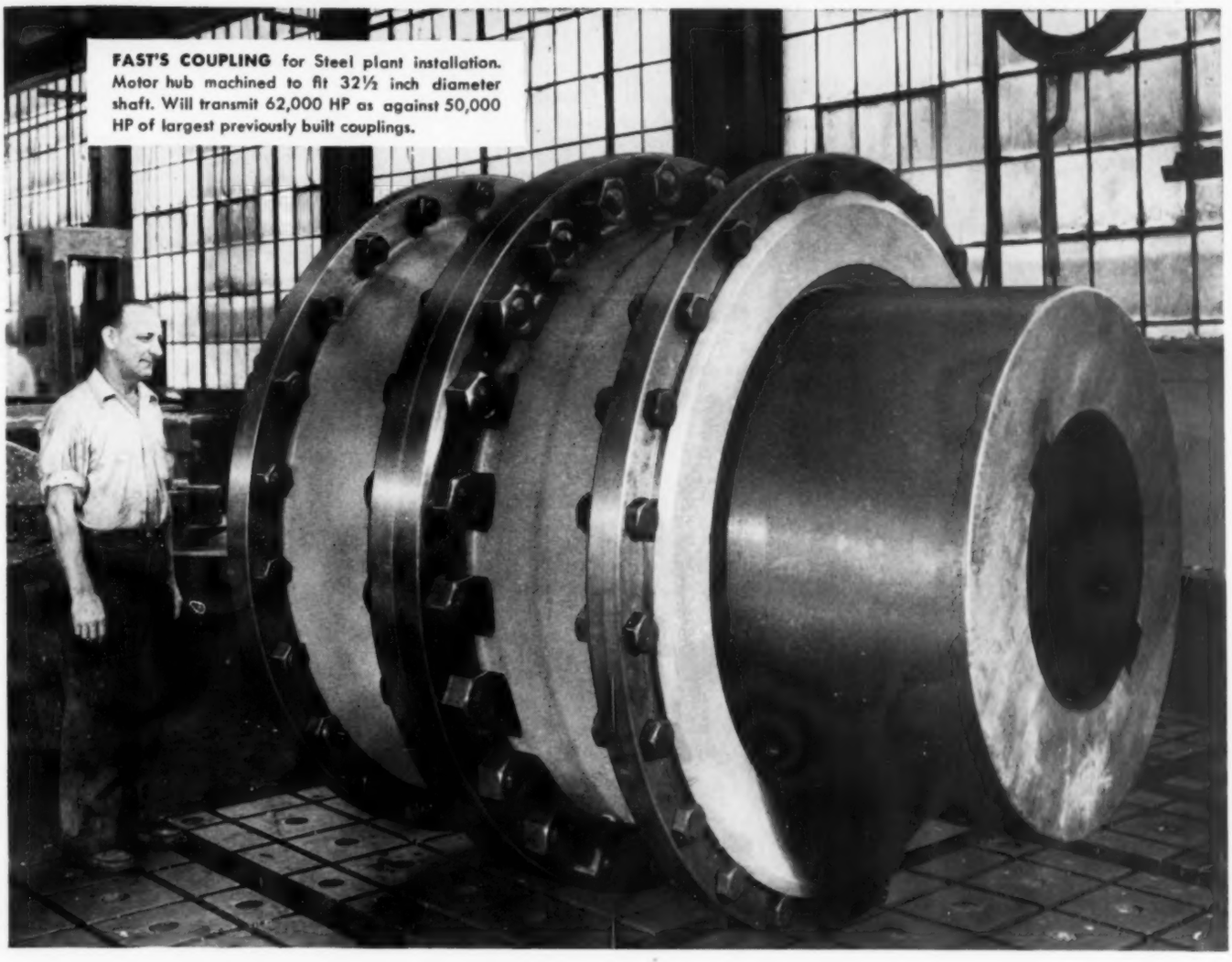
A sleeve, sealed with "O" rings at two places, prevents dust or other foreign material from entering the area where the solenoid armature contacts the valve plunger, thus assuring dust-free operation at this point.

The top half of the newly designed two-piece cover for the solenoid overlaps and fits tightly over the bottom half of the cover protecting the solenoid from dust, oil, grit and foreign particles, even those blown around during "cleaning up" operations. The top half of the cover can be removed by simply loosening two screws. This provides easy access to the interior of the bottom half of the cover which is amply sized; to provide space in which to work comfortably when connecting the solenoid leads to the control wiring; and permits the splice when finished to be tucked away conveniently in the cover rather than pulled in to the cable or piping.

The manufacturer states that these design and construction changes have been added to all sizes of "O" type solenoid valves, and will be furnished on all future shipments, as standard, without additional cost.

Book Reviews . . .

▲ **"Chemical Industry Facts Book,"** second edition, just published, reports a four-fold chemical industry sales growth, 1939 through 1954. The



FAST'S COUPLING for Steel plant installation. Motor hub machined to fit 32½ inch diameter shaft. Will transmit 62,000 HP as against 50,000 HP of largest previously built couplings.

WORLD'S LARGEST INDUSTRIAL GEAR-TYPE COUPLING

To make a coupling that will transmit 62,000 HP and compensate for errors in alignment . . . that's more than a man-sized job.

But Koppers took on the project and this Fast's Self-Aligning Coupling is the result.

After six months of machining and assembly, this huge, *all metal* coupling is on its way to installation in a Milano, Italy, steel mill where it will carry power to a Mesta, 110-inch, four-high reversing plate mill.

It will transmit power from an electric motor to the equipment, and, at the same time, compensate for shaft misalignment and lateral float, give maximum power transmission efficiency, eliminate breakdowns and costly down-time.

WHAT'S YOUR COUPLING PROBLEM?

This mammoth Fast's Coupling is just one example of the outstanding jobs which Koppers is equipped to handle. 35 years of manufacturing "know-how" go into the production of *all* Fast's Couplings, large and small alike. Engineering specialists, experienced in designing Fast's Couplings for special applications, are well equipped to solve your coupling problems.

Remember, there's a Fast's Coupling for every power transmission application. Next time you have a coupling problem, call on Koppers . . . always ready to serve you. No obligation, of course. Also, for full details on Fast's Couplings for industry, mail this coupon.

THE ORIGINAL **Fast's Couplings**

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METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

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Gentlemen: Send me FREE, Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

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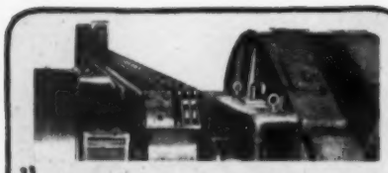

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says—PITTSBURGH TUBE COMPANY

"Our 70,000 pound Draw Bench was designed to operate at a maximum of 80 feet per minute, full load. We decided to increase the drawing speed on lighter tubing to 100 and 104 feet per minute. This overloaded the Speed Reducer, however, causing it to overheat. We tried four different makes of oils without success before trying LUBRIPLATE A.P.G. 90. With LUBRIPLATE, we are able to pull heavier tubing than before at 104 feet per minute without the Reducer overheating."

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Maintenance Engineer

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LUBRIPLATE is available in grease and fluid densities for every purpose... LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

1939 sales figure of $4.3 billion grew to $20.3 billion in 1954.

Crediting research and development, in which the chemical industry invests an average of $300,000,000 per year as the springboard for expansion, the Facts Book explains that the chemical industry concentrates its efforts on three things:

1. The creation of new materials that serve human needs better than existing materials.
2. The improvement of materials so that they serve human needs more effectively.
3. The improvement of existing processes in ways that reduce costs and prices, thereby making products of chemistry more generally available.

Tracing the chemical industry's modern growth from the needs of World War I, the Facts Book now notes that the products of the industry are essential to the operation of every other United States industry —some 70 in all. Today the production value of chemicals made in more than 11,000 producing plants accounts for 10 per cent of all U. S. manufacturing output. In terms of total assets the chemical industry ranks fourth among all this nation's manufacturing industries.

"ASTM Standards on Electrical Insulating Materials (With Related Information)," 660 pp, heavy paper Cover, 6 x 9, $5.50, includes the latest ASTM methods of testing and specifications for electrical insulating materials prepared by ASTM Committee D-9. The book includes 60 methods of test, 17 specifications, 3 recommended practices, and one list of definitions. Thirty-three of the designations are either new or have been revised since the last edition of the compilation was published in March of 1953. This compilation includes revisions accepted as late as February 3, 1955.

The compilation will be of great value and use to manufacturers, suppliers, and consumers of electrical insulating materials and electrical machinery and devices ranging from the heaviest of generating equipment through the electrical appliance field to the lightest of electronic components. Copies may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $5.50 each.

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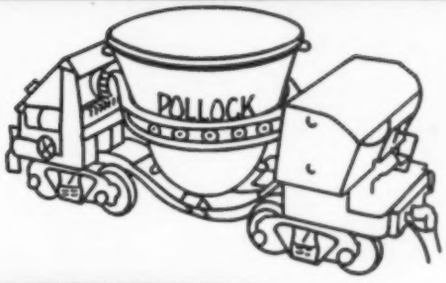
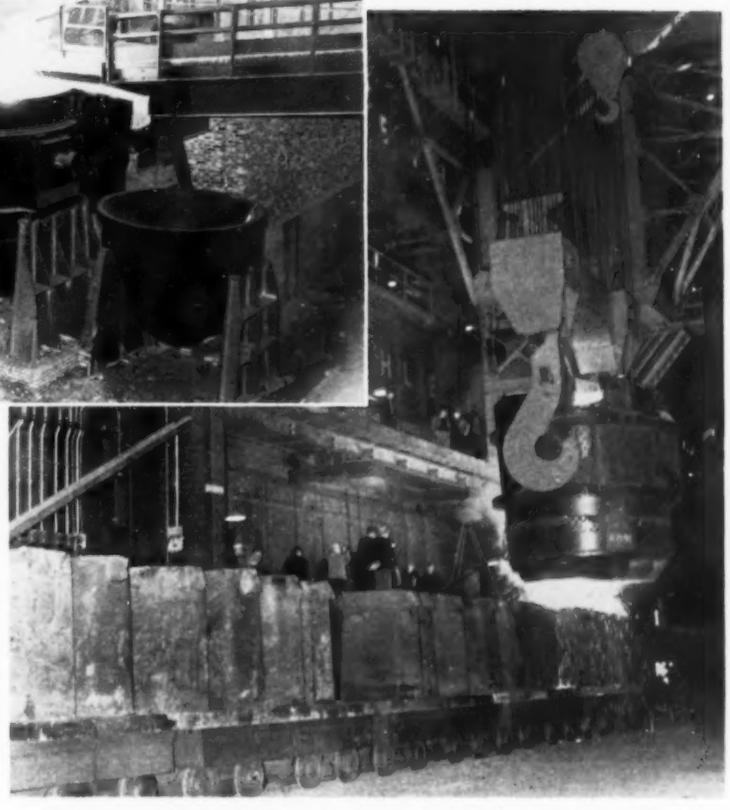
expansion at Portsmouth includes modern Pollock equipment



A 250-ton Pollock ladle, ready to receive the first heat made at Portsmouth's new Open Hearth Shop.



Teeming molten steel from a 250-ton Pollock ladle into ingot moulds at Portsmouth.

Pollock equipment took a prominent part in the pouring of the first heat in the new Open Hearth Shop at the Portsmouth Division of Detroit Steel Corporation. 250-Ton Open Hearth Ladles, 400 Cu. Ft. Self-Dumping Slag Cars and Ladle and Slag Pot Stands are the Pollock equipment ordered by Portsmouth to help provide an increased volume of molten metal to feed its finishing mills.

We at the William B. Pollock Company are proud to be an important supplier to Portsmouth of Open Hearth equipment, and we take great pleasure in congratulating the Detroit Steel Corporation on the progressive steps taken by them to meet current conditions, and we wish them continued success.

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● **OUTSTANDING MECHANICAL DESIGN for easy installation, interchangeability, and simplified servicing.** All units, including pyrometer unit, electronic control unit, and proportional-input unit are separate. The electronic control and proportional-input units plug in. No routine adjusting or attention needed. Series 536 Indicating Free-Vane Electronic Pyrometer Controllers are available as thermocouple and radiation pyrometers in ranges up to 4000° F. for L, H, LH, HOH, and LNH control and for L and H with proportional input control. Write for Bulletin P1248. The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. 3.10

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There are detailed descriptions of all the latest standard seal designs including the new LPD and RPD . . . as well as those for special applications. Uses in petroleum, automotive, mining, earth-moving, aviation, iron and steel, machine tool and process industries are covered thoroughly.

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Please send me free copy of new Clipper Oil Seal Brochure (PK-71A)

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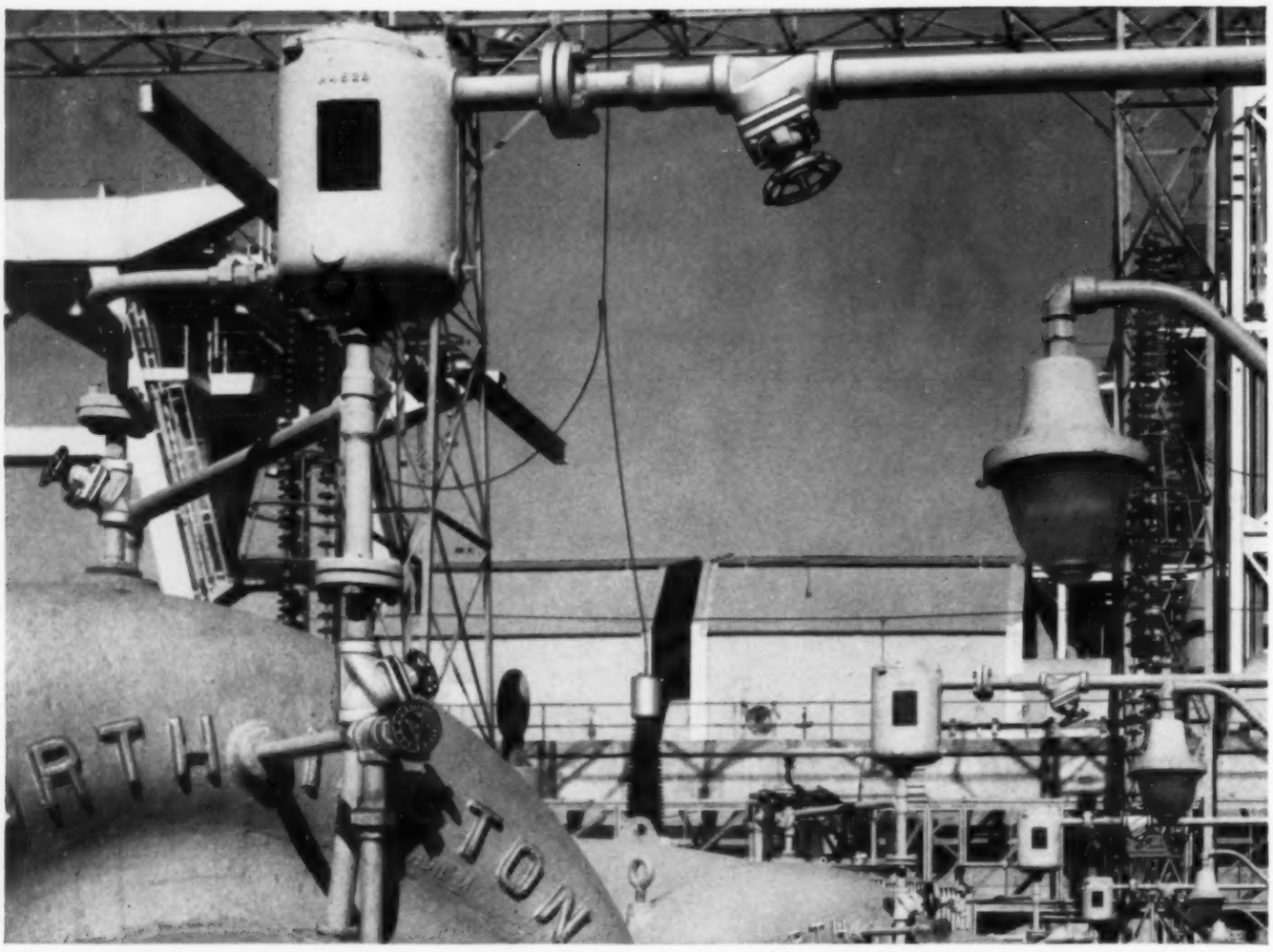

Corrosive circulating water tamed here by these CRANE VALVES

THE CASE HISTORY—Almost 2 years' operation without any maintenance of valves on circulating water lines to condensers, and on priming and instrumentation systems—with no trouble in sight. That's the experience of Southern California Edison Company's 280,000 k.w. steam station at Etiwanda with Crane Packless Diaphragm Valves.

The plant's engineers knew that sediment in recirculated water would quickly cut out the seats in ordinary valves and its corrosive elements would attack working parts to make valve operation difficult.

Not so with Crane Packless Diaphragm Valves. Their sealed bonnet keeps working parts out of contact with line fluid—free of corrosive effects. Separate disc construction with pliable insert resists erosion—seats tightly even on foreign particles. Large or small, these valves operate easily with fewer turns to the cycle. Typical Crane quality throughout—they're made better to do the job better—a bigger value for the thrifty buyer.

CRANE No. 1610 PACKLESS DIAPHRAGM VALVES

No packing to maintain. Neoprene diaphragm has longer life because it seals the bonnet only—is not subject to the cutting and crushing encountered when also required to do the seating. Separate disc gives control of fluid even should diaphragm fail. Wide selection of materials and sizes. Write for folder AD-1942 or see your Crane Representative.

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The Word We Dreaded

My husband and I were together when the phone rang. He got up to answer it and I held my breath as I heard his quiet, "Yes, Doctor?"

Then he put the receiver down carefully. His face, when he turned to me, was gaunt and lined, but he was trying to smile.

"Was it—the laboratory tests?" I asked.

He nodded. "We'd better get my bag packed," he said gently. "They want me in the hospital this evening."

We had realized for months that something was wrong. But the pressure of his business postponed action. "Guess I'm a little off my feed," was all he would say.

It took our family physician only ten minutes to change that attitude. He made an immediate appointment with a specialist. And at the end of an anguished week we knew. The laboratory tests confirmed the word we dreaded—"Cancer."

That was a year ago. Modern cancer research saved my husband. That... and the surgeon's skill, the strength of our faith and his own fighting heart. He is alive and well today. For us the story has had a happy ending.

Yet it *isn't* ended. When we think of the thousands of other families tragically broken every year, we feel we still have work to do. Many types of cancer *can be cured* if caught in time. We tell our friends, "If there are symptoms you don't understand, see your doctor at once." And we *give* to support the constant research of the American Cancer Society in finding the causes and reducing the incidence of cancer.

Strike back at CANCER . . . man's cruelest enemy . . . GIVE

American Cancer Society

GENTLEMEN:

I want to help conquer Cancer.

☐ Please send me free information about Cancer.

☐ Enclosed is my contribution of $_____ to the Cancer Crusade.

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(MAIL TO: CANCER, c/o your town's Postmaster)

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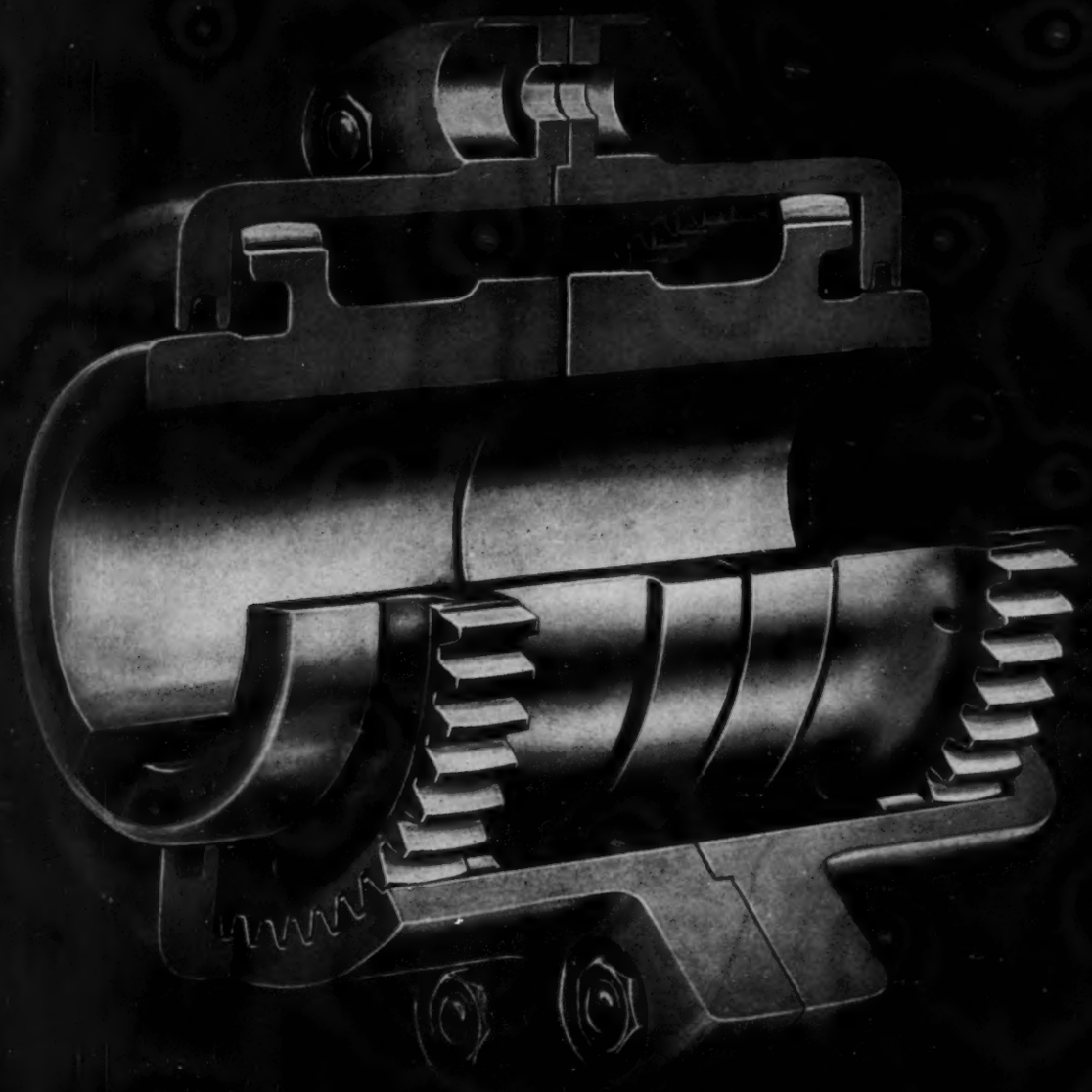

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No. 170

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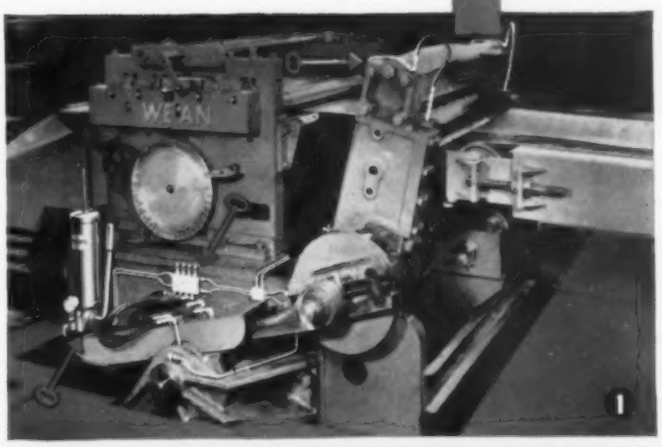

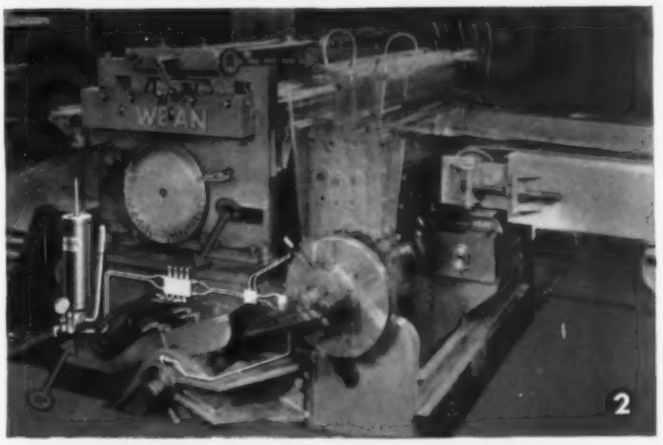

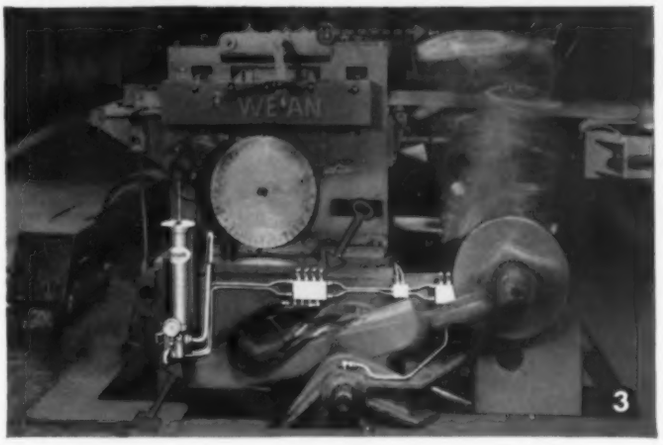

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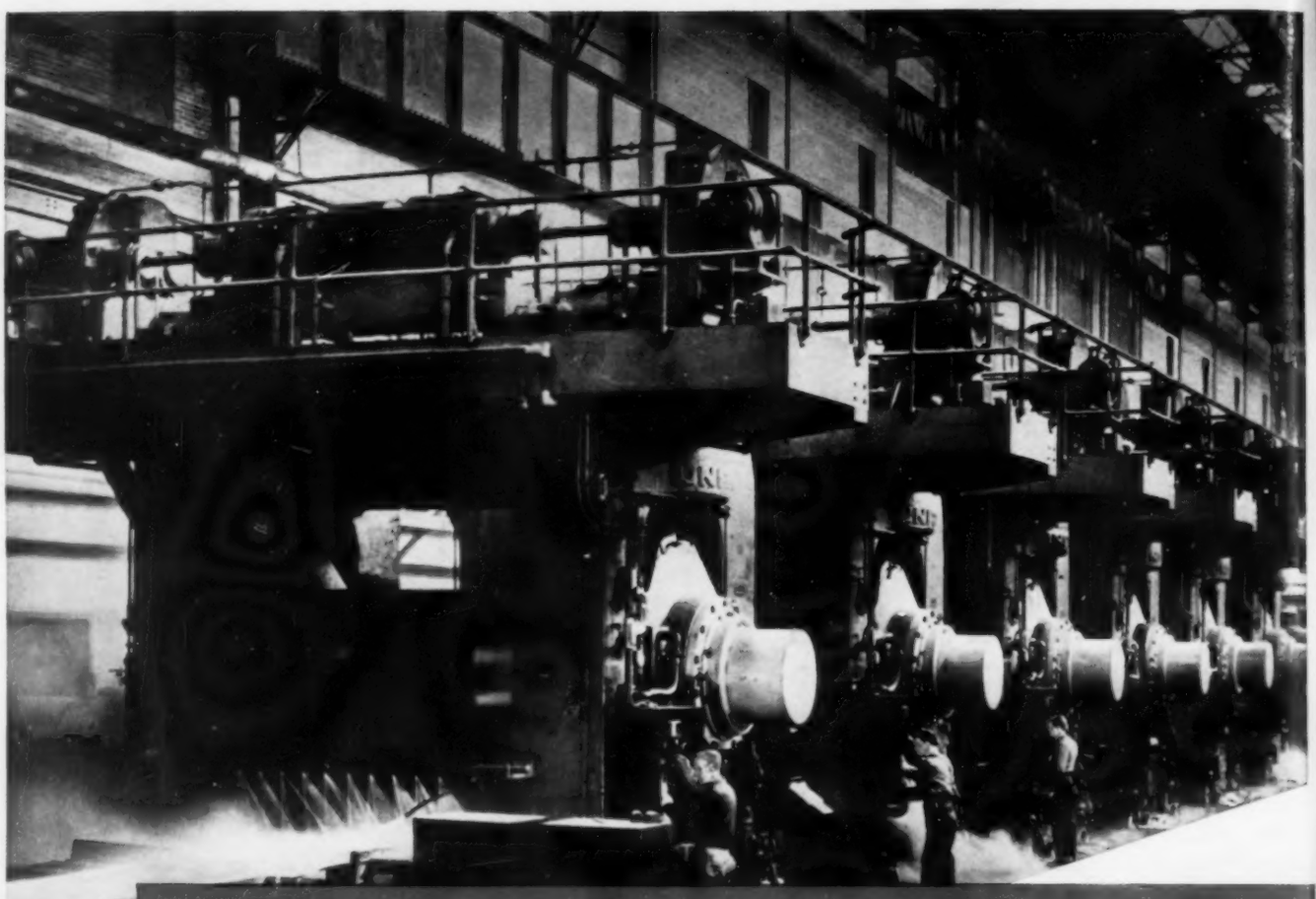

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